december 1959
the
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oceedings of the IRE

in this issue

DEC 13 1959
CHICAGO

POISSON, SHANNON, AND THE RADIO AMATEUR
ELECTRONIC SCANNING FOR INFRARED
FREQUENCY MULTIPLICATION
WITH NONLINEAR CAPACITORS
AMMONIA BEAM MASER
COAXIAL HELICAL RESONATORS
DIGITAL RATE FREQUENCY CONTROL
TRANSACTIONS ABSTRACTS
ABSTRACTS AND REFERENCES
PROCEEDINGS ANNUAL INDEX

Electronic Scanning of Infrared Images: Page 2069

FILTERS FOR ALL APPLICATIONS FROM STOCK

HERMETICALLY SEALED TO MIL-T-27A & MIL-F-18327 SPECS.

Write For NEW Catalog

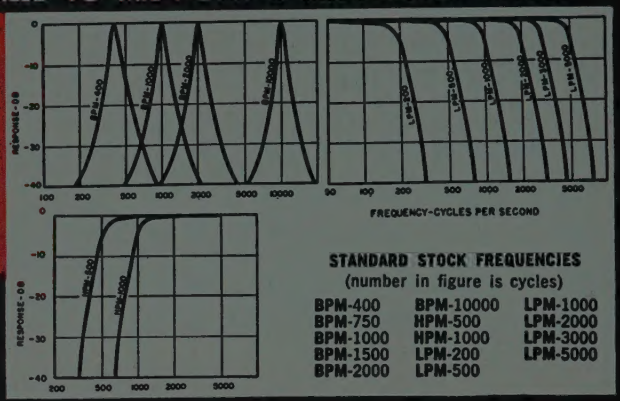
MINIFILTERS

New Minifilters provide almost the same characteristics (with attenuation only slightly less) as the industry's standard interstage and line filters immediately below.

BPM band pass units are 10K input, output to grid; 2:1 gain. Attenuation is approximately 2 db ±3% from center frequency, then 35 db per octave.

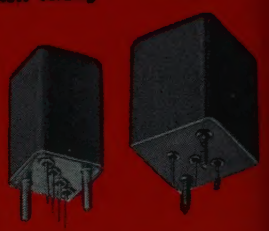
HPM high pass units; loss of less than 6 db at cut-off frequency; attenuation of 30 db at .67 cut-off frequency, 40 db at .6 cut-off frequency. Input and output 10K.

LPM low pass units; loss of less than 6 db at cut-off frequency; attenuation of 30 db at 1.5 cut-off frequency, 40 db at 1.65 cut-off frequency. Input and output 10K.



STANDARD STOCK FREQUENCIES
(number in figure is cycles)

BPM-400	BPM-10000	LPM-1000
BPM-750	HPM-500	LPM-2000
BPM-1000	HPM-1000	LPM-3000
BPM-1500	LPM-200	LPM-5000
BPM-2000	LPM-500	



BPM case (MIL AF) ¾ x ¾ x 1⅛" Weight....1 oz.

HPM and LPM case (MIL AG) 1 x 1 x 1⅝" Weight....2¼ oz.

INTERSTAGE & LINE

These six basic types cover most popular filter applications and frequencies.

BMI band pass units are 10K input, output to grid; 2:1 gain. Attenuation is approximately 2 db at 3% from center frequency, then 40 db per octave.

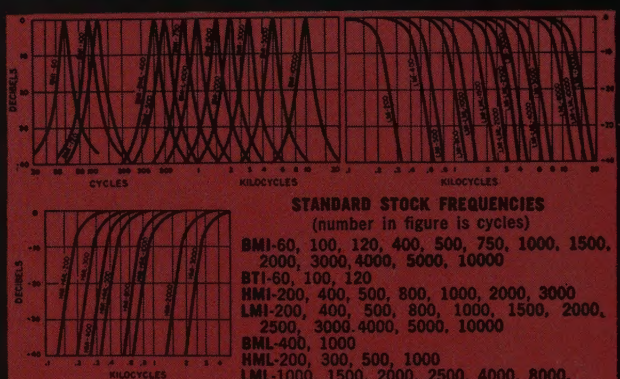
HMI high pass units are 10K in and out. Attenuation is less than 6 db at cut-off frequency and 35 db at .67 cut-off frequency.

LMI low pass units are 10K in and out. Attenuation is less than 6 db at cut-off frequency and 35 db at 1.5 cut-off frequency.

HML high pass filters are same as HMI but 500/600 ohms in and out.

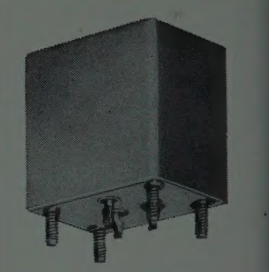
LML low pass filters are same as LMI but 500/600 ohms in and out.

BML band pass units are same as BMI but 500/600 ohms input, output to grid, 9:1 gain.



STANDARD STOCK FREQUENCIES
(number in figure is cycles)

BMI-60, 100, 120, 400, 500, 750, 1000, 1500, 2000, 3000, 4000, 5000, 10000
BTI-60, 100, 120
HMI-200, 400, 500, 800, 1000, 2000, 3000
LMI-200, 400, 500, 800, 1000, 1500, 2000, 2500, 3000, 4000, 5000, 10000
BML-400, 1000
HML-200, 300, 500, 1000
LML-1000, 1500, 2000, 2500, 4000, 8000, 10000, 12000



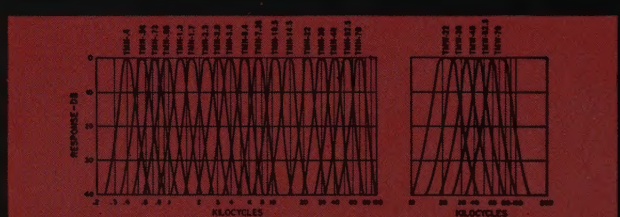
Base ..... 1⅜ x 1 11/16"
Height, BMI, LMI, BML..... 1⅝"
Height, HMI, HML, LML ..... 2½"
Weight ..... 6 oz. and 9 oz.

TELEMETERING BAND PASS

UTC standard telemetering filters provide extreme miniaturization with maximum stability, a complete set of 18 filters taking 19 cubic inches. They are 100K in and out and have an insertion loss of less than 6 db, 4 pin header for small Winchester socket.

TMN units are within 3 db at ± 7.5% of center frequency . . . down more than 18 db at ± 25% . . . more than 40 db beyond 1.75 and .58 center frequency.

TMW are within 3 db at ± 15% of center frequency . . . down more than 20 db at ± 50% . . . more than 40 db beyond 2.5 and .4 center frequency.



STANDARD STOCK FREQUENCIES
(number in figure is KC)

TMN- .4	TMN-1.7	TMN- 5.4	TMN-30	TMW-22
TMN- .56	TMN-2.3	TMN- 7.35	TMN-40	TMW-30
TMN- .73	TMN-3.0	TMN-10.5	TMN-52.5	TMW-40
TMN- .96	TMN-3.9	TMN-14.5	TMN-70	TMW-52.5
TMN-1.3		TMN-22		TMW-70

TMN-2.3 thru TMW-70 ⅜ x ⅜ x 1⅜" Weight....1.2 oz.

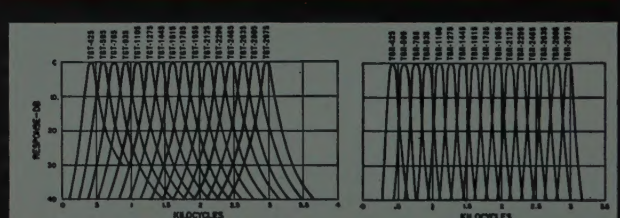
TMN-.4 thru TMN-1.7 1¼ x 1⅝ x 2" Weight....3.5 oz.

TELEGRAPH TONE CHANNEL

These band pass filters for multiplex transmitting and receiving provide maximum stability in miniature sizes. Both receiving and transmitting types are 600 ohms in and out, and employ 7 terminal header for sub-miniature 7 pin socket.

TGT transmitting filters are within 3 db at ± 42.5 cycles from center frequency . . . down more than 16 db at ± 170 cycles . . . down more than 7.5 db at adjacent channel crossover.

TGR receiving filters are within 3 db at ± 42.5 cycles from center frequency . . . down more than 30 db at ± 170 cycles . . . down more than 15 db at adjacent channel crossover.



TRANSMITTING		STANDARD STOCK FREQUENCIES (number in figure is cycles)	RECEIVING	
TGT-425	TGT-1785		TGR-425	TGR-1785
TGT-595	TGT-1955		TGR-595	TGR-1955
TGT-765	TGT-2125		TGR-765	TGR-2125
TGT-935	TGT-2295		TGR-935	TGR-2295
TGT-1105	TGT-2465		TGR-1105	TGR-2465
TGT-1275	TGT-2635		TGR-1275	TGR-2635
TGT-1445	TGT-2805		TGR-1445	TGR-2805
TGT-1615	TGT-2975		TGR-1615	TGR-2975

TGT CASE 1½ x 1½ x 2½" Weight....8 oz.

TGR CASE 1½ x 1½ x 4½" Weight....15 oz.

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VOLUME 47, NUMBER 12

December, 1959

published monthly by The Institute of Radio Engineers, Inc.

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COVER

An infrared "window" made of silicon can be made locally opaque by bombarding it with electrons. This phenomenon has been utilized by the Philco Corp. in a novel system for scanning infrared images electronically. The image is dissected by producing a moving opaque spot on the window by means of a scanning electron beam, as described on page 2069.

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Thirty days advance notice is required for change of address. Price per copy: members of the Institute of Radio Engineers, one additional copy $1.25; non-members $2.25. Yearly subscription price: to members $9.00, one additional subscription $13.50; to non-members in United States, Canada, and U. S. Possessions $18.00; to non-members in foreign countries $19.00. Second-class postage paid at Menasha, Wisconsin under the act of March 3, 1879. Acceptance for mailing at a special rate of postage is provided for in the act of February 28, 1925, embodied in Paragraph 4, Section 412, P. L. and R., authorized October 26, 1927. Printed in U.S.A. *Copyright © 1959 by the Institute of Radio Engineers, Inc.*

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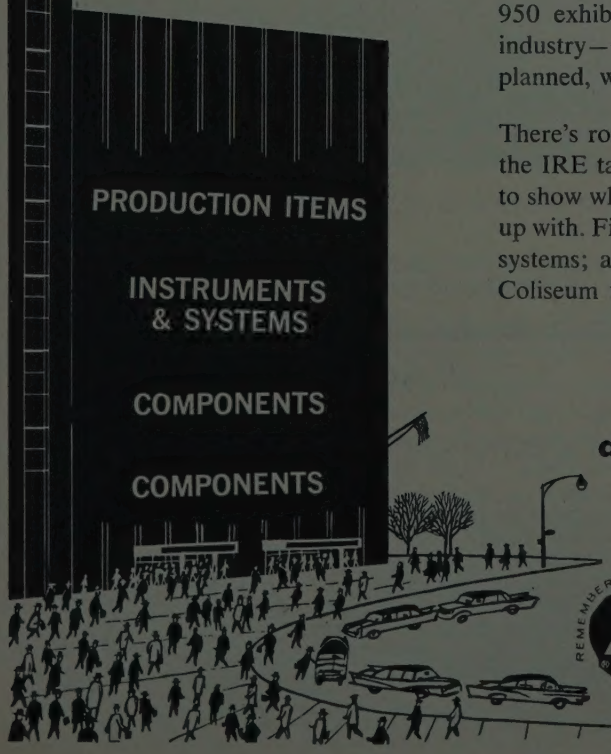
60,052

and we're set to handle even more of you in 1960 looking for

NEW IDEAS *in* RADIO-ELECTRONICS!

Yes, the IRE NATIONAL CONVENTION and RADIO ENGINEERING SHOW is growing bigger every year, and drawing more people—950 exhibitors representing 80% of the productive capacity of your industry—60,052 registrants last year! Yet, it's one of the most well planned, well executed gatherings you'll ever see!

There's room to move around, room to see all you want to see because the IRE takes over all *4 floors* of the giant Coliseum in New York City to show what your huge, fast moving radio-electronics industry is coming up with. First and second floors for components; third for instruments and systems; and fourth for production items. Follow the engineers to the Coliseum for NEW IDEAS IN RADIO-ELECTRONICS, 1960!



The IRE NATIONAL CONVENTION
Waldorf-Astoria Hotel
and The RADIO ENGINEERING SHOW
Coliseum, New York City

MARCH 21, 22, 23, 24

The Institute of Radio Engineers
1 East 79th St., New York 21, N. Y.

Winthrop Sullivan and Alan Swanson, members of our Department of Medical and Biological Physics recently demonstrated a new device to physicians attending the Convention of the American Physiological Society. This device, an ingestible pressure transensor, will be of great value to the medical researcher.

Ingestible Medical Pressure Transensor

For years research workers have sought a painless method for obtaining data concerning the activity of the patient's gastrointestinal tract. Until recently, the only methods available necessitated the patient's swallowing a combination of tubes and wires that led to an external instrument. The passage of this paraphernalia into the gastrointestinal tract frequently caused the patient considerable discomfort. In many cases, the discomfort caused by the tubes and wires reflected itself in the recorded data.

The obvious need for a method of measuring gastrointestinal activity led to development of the Pressure Transensor, a miniature ingestible pressure-sensitive telemetry capsule.

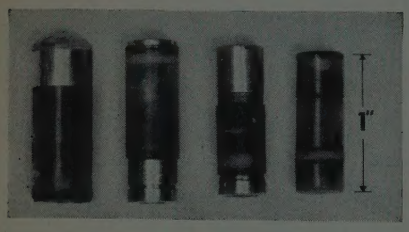


Figure 1. Progressive miniaturization of transensor

Developed from earlier work done by RCA and by the Rockefeller Institute for Medical Research, the capsule contains a pressure transducer that modulates the frequency of an internal transistor oscillator that is powered by a tiny mercury battery. The signal transmitted from the ingested capsule is received by an antenna located outside the body and is demodulated by an FM receiver that produces a voltage proportional to the internal pressure.

A great advantage of the Pressure Transensor is that its small size enables it to pass easily through the gastrointestinal tract and to be recovered and used again. Earlier models have been used in an experimental test program carried out during the last two years by Dr. John Farrar and his associates at the Veterans Administration Hospital in New York; all results indicate that the Transensor causes no discomfort to the patient.

Data obtained from Dr. Farrar's experiments are quite promising.* From records similar to those in the accompanying diagrams, it has been found that most pressures in the gastrointestinal tract range from 0 to 3 psi. Furthermore, the testing of subjects with certain intestinal diseases has resulted in records that appear to be markedly different from those obtained from normal subjects as can be seen in Figure 2. The importance of the data obtained by the Pressure Transensor will be known only after more extensive clinical investigation. Only then will the frequencies and amplitudes of the pressure waves recorded by the Transensor in the gastrointestinal tract come to be meaningful.

The Pressure Transensor is only the first in a series of instruments using telemetry that our Department of Medical and Biological Physics plans to produce. To gain a complete picture of gastrointestinal activity, variables other than pressure must be recorded. At present, we are experimenting with a Transensor capable of measuring temperature, and we are interested in designs to monitor acidity and to detect the presence of blood in the gastrointestinal tract.

The telemetering sensor may not be limited entirely to the study of the gastrointestinal tract. The development of small, short-range telemetering sensors that can be either swallowed or attached inconspicuously to the subject's clothing or person could be used in the field of space medicine to monitor a number of physiological variables. These sensors would not require a complexity of wires and tubes leading to the subject, and the data obtained could provide a key to the behavior of human beings under stress.

A complete bound set of our third series of articles is available on request. Write to Harold Hechtman at AIL for your set.

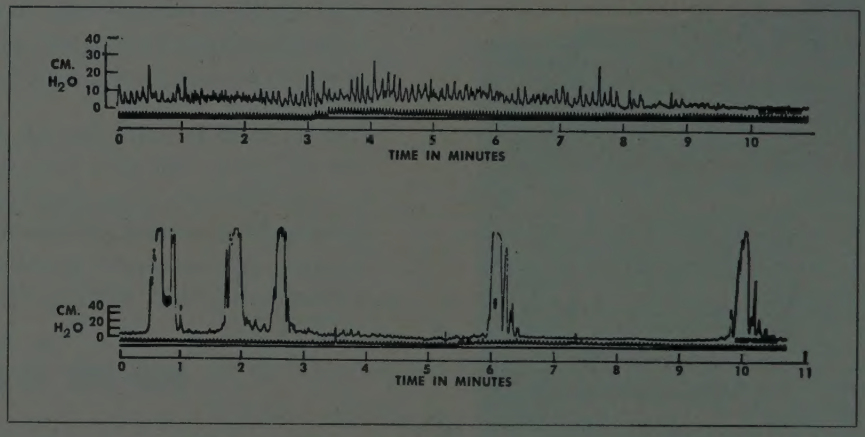


Figure 2. Upper record, example of the normal intraluminal pressure of the jejunum. Lower record, intraluminal pressure of the ileum in a patient with the malignant carcinoid syndrome.

* "Recording of Intraluminal Gastrointestinal Pressures By a Radiotelemetering Capsule," by John T. Farrar, M.D., and James S. Bernstein, M.D.

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A look at the small *actual sizes* illustrated, emphasizes how ideal they are for use in miniature electronic equipment with either conventional wiring or printed wiring boards.

Get complete data on these dependable minified resistors, **write for Engineering Bulletin 7410.**

TAB-TYPE BLUE JACKETS: For industrial applications, a wide selection of wattage ratings from 5 to 218 watts are available in Sprague's famous Tab-Type Blue Jacket close-tolerance, power-type wirewound resistors. Ideal for use in radio transmitters, electronic and industrial equipment, etc. **For complete data, send for Engineering Bulletin 7400A.**

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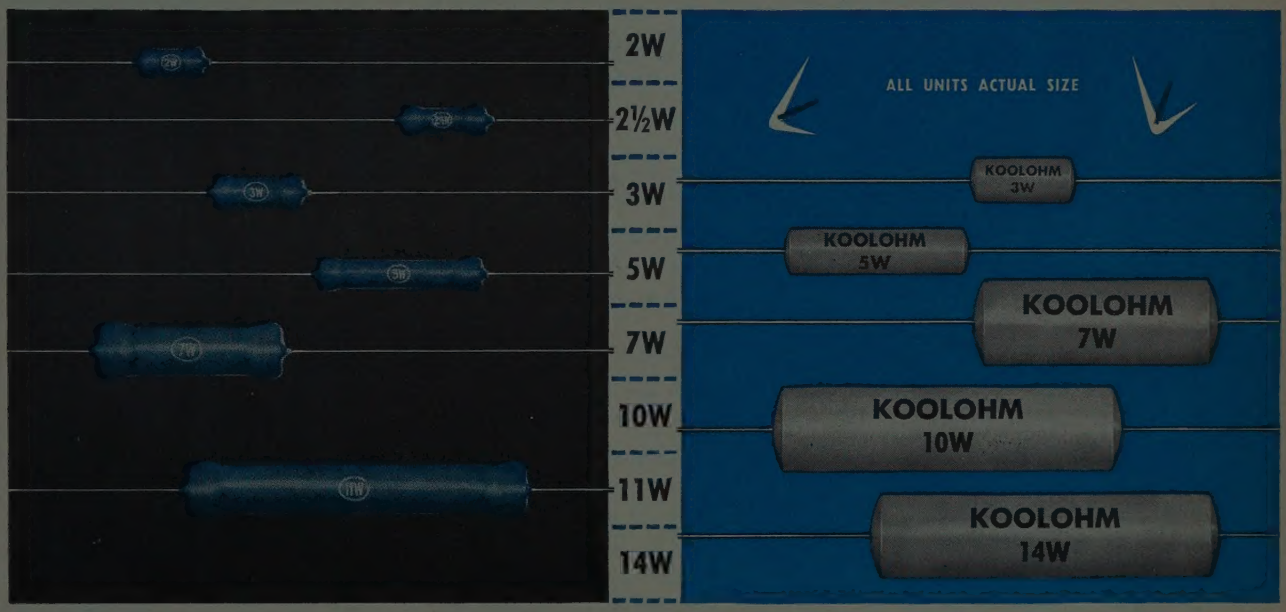
KOOLOHM®

INSULATED-SHELL POWER RESISTORS

New Koolohm construction features include welded leads and winding terminations—Ceron ceramic-insulated resistance wire, wound on special ceramic core—multi-layer non-inductive windings or high resistance value conventional windings—sealed, insulated, non-porous ceramic outer shells—*aged-on-load* to stabilize resistance value.

You can depend upon them to carry maximum rated load for any given physical size.

Send for Engineering Bulletin 7300 for complete technical data.



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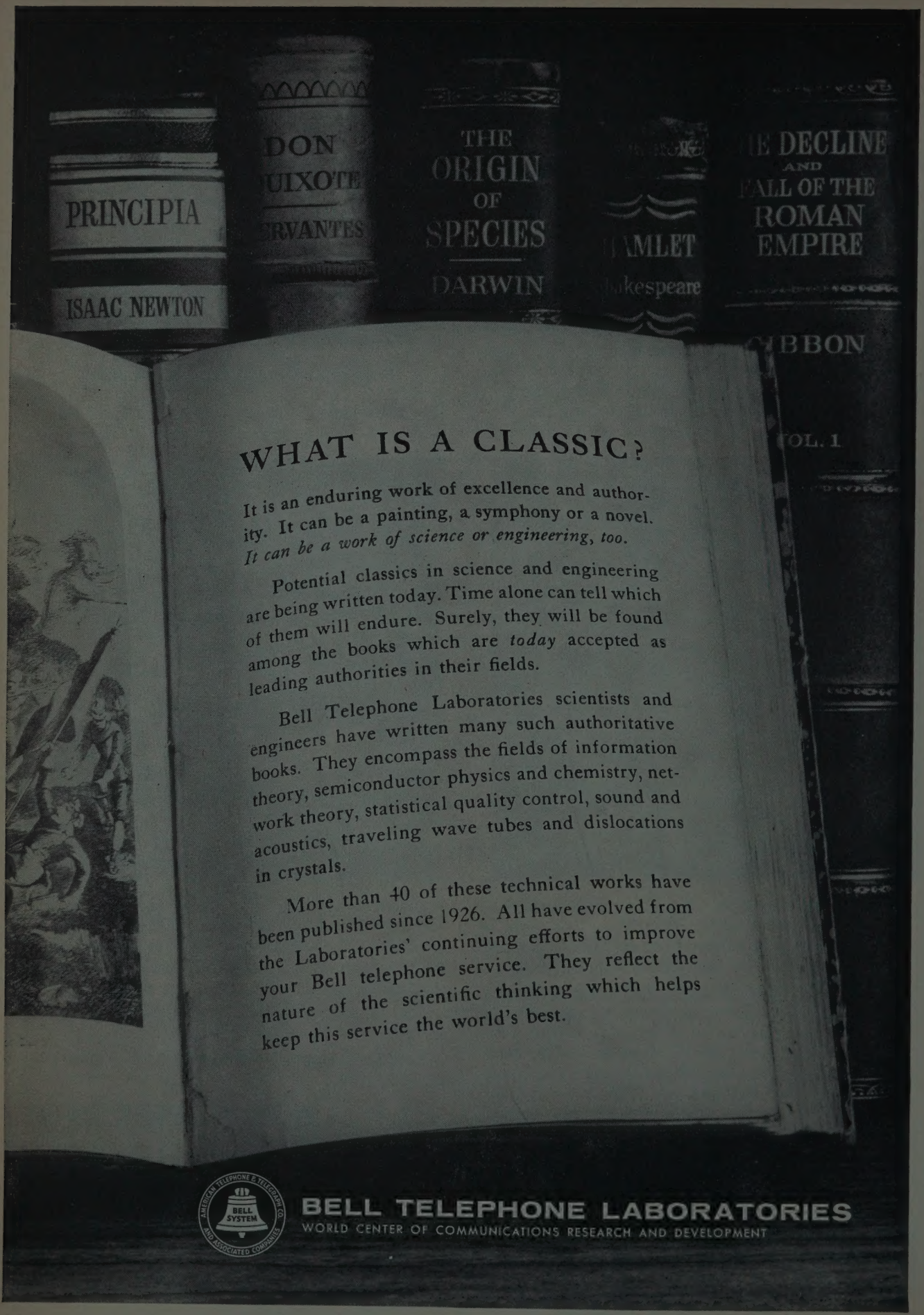

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Potential classics in science and engineering are being written today. Time alone can tell which of them will endure. Surely, they will be found among the books which are *today* accepted as leading authorities in their fields.

Bell Telephone Laboratories scientists and engineers have written many such authoritative books. They encompass the fields of information theory, semiconductor physics and chemistry, network theory, statistical quality control, sound and acoustics, traveling wave tubes and dislocations in crystals.

More than 40 of these technical works have been published since 1926. All have evolved from the Laboratories' continuing efforts to improve your Bell telephone service. They reflect the nature of the scientific thinking which helps keep this service the world's best.

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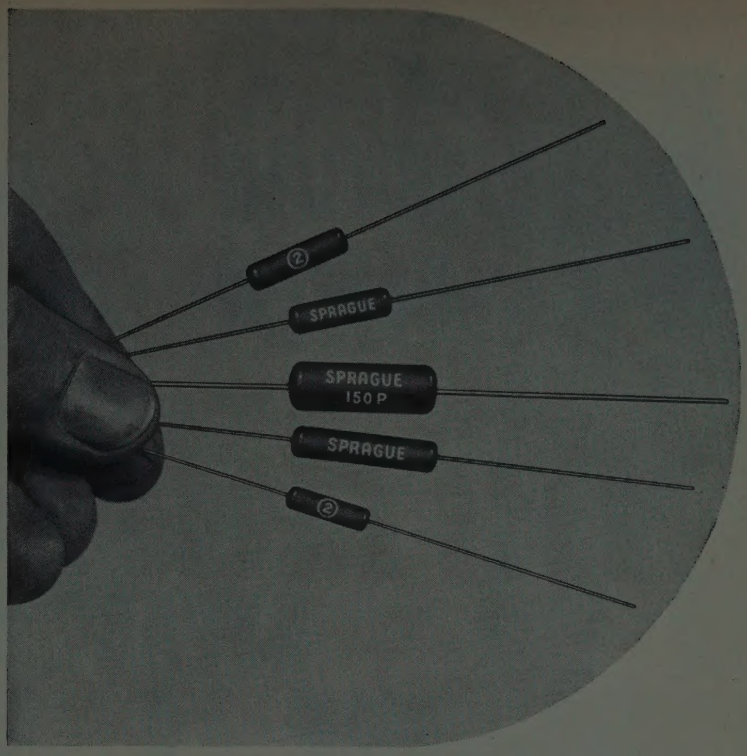

Miniature

PROKAR® 'D' Molded Capacitors

––with improved moisture resistance and a new dual dielectric for 125 C operation without voltage derating

Sprague's new and improved PROKAR 'D' Molded Tubular Capacitors meet the need for *ever smaller* molded capacitors capable of withstanding 125 C operation in military, commercial, and industrial electronics.

Key to the new design is an improved processing technique which greatly increases moisture resistance. The new dual dielectric used in Type 150P Capacitors combines the dielectric strength of the highest grade capacitor tissue with the effective moisture resistance of plastic film, giving these miniature units high insulation resistance plus extended life at 125 C. The impregnant used is still the same exclusive high temperature organic material which marked a milestone in molded capacitor development for the original Prokar series.

The improved performance of PROKAR 'D' Capacitors is worth investigating—greater resistance to humidity, high insulation resistance (minimum of 10 megohm-microfarads at 125 C), moderate capacitance change with temperature, longer life, and improved reliability.

For complete specifications on Type 150P PROKAR 'D' Molded Tubular Capacitors, write for Engineering Bulletin 2300 to Technical Literature Section, Sprague Electric Company, 235 Marshall St., North Adams, Mass.

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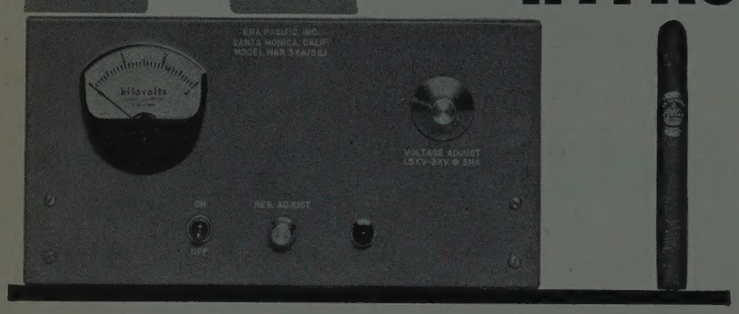

These unique designs provide high voltage regulated DC outputs utilizing solid state devices and magnetic components. HYPAC models are compact, rugged units which eliminate the drawbacks of conventional, cumbersome circuits. Typical applications include memory or storage tubes, traveling wave tubes, klystron powering, cathode ray indicators, accelerators, and all types of laboratory and industrial applications. HYPAC's are available in 4 models* with input of 115 vac @ 60 cps, line regulation ±.5% for full rated line change, load regulation ±.5% for 20% to 100% load, ripple 1% rms. ® Reg. U.S. Pat. Off.

* MODELS

HAR1KA/5(L)	Output Voltage 500—1000 vdc, Output Current	5 ma,	$325. fob Factory
HAR3KA/5(L)	Output Voltage 1500—3000 vdc, Output Current	5 ma,	$350. fob Factory
HAR5KA/3(L)	Output Voltage 2500—5000 vdc, Output Current	3 ma,	$385. fob Factory
HAR10KA/1.5(L)	Output Voltage 5000-10,000 vdc, Output Current	1.5 ma,	$440. fob Factory

Write For Complete Technical Bulletin — Catalogue #501

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Meetings with Exhibits

● As a service both to Members and the industry, we will endeavor to record in this column each month those meetings of IRE, its sections and professional groups which include exhibits.

Δ

February 3-5, 1960

PGMIL Winter Meeting, Biltmore Hotel, Los Angeles, Calif.

Exhibits: Mr. Einer Ingebretson, Summers Gyroscope Co., Santa Monica, Calif.

March 21-24, 1960

Radio Engineering Show and IRE National Convention, Waldorf-Astoria Hotel and New York Coliseum, New York, N.Y.

Exhibits: Mr. William C. Copp, Institute of Radio Engineers, 72 West 45th St., New York 36, N.Y.

April 3-8, 1960

Sixth Nuclear Congress, New York Coliseum, New York, N.Y.

Exhibits: Mr. F. M. Howell, c/o EJC, 29 W. 39th St., New York 18, N.Y.

April 20-22, 1960

SWIRECO, Southwestern IRE Regional Conference & Electronics Show, Shamrock-Hilton Hotel, Houston, Texas.

Exhibits: Mr. A. D. Seixas, SWIRECO, P.O. Box 22331, Houston, Texas.

May 2-4, 1960

National Aeronautical Electronics Conference, Dayton Biltmore Hotel, Dayton, Ohio.

Exhibits: Mr. Edward M. Lisowski, General Precision Lab., Inc., Suite 452, 333 West First St., Dayton 2, Ohio.

May 2-6, 1960

Western Joint Computer Conference, Fairmont Hotel, San Francisco, Calif.

Exhibits: Mr. H. K. Farrar, Pacific Tel. & Tel. Co., 140 New Montgomery St., San Francisco 5, Calif.

May 23-25, 1960

Seventh Regional Technical Conference & Trade Show, Olympic Hotel, Seattle, Wash.

Exhibits: Dr. Frank Holman, Boeing Airplane Co., 10708 39th Ave., S.W., Seattle 66, Wash.

May 24-26, 1960

Armed Forces Communications & Electronics Association Convention and Exhibit, Sheraton-Park Hotel, Washington, D.C.

Exhibits: Mr. William C. Copp, 72 West 45th St., New York 36, N.Y.

June 27-29, 1960

National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D.C.

Exhibits: Mr. L. David Whitelock, Bu-Ships, Electronics Div., Dept. of Navy, Washington, D.C.

(continued on page 10A)

For High Accuracy — Broad Band Noise - Figure Measurement

KAY *Therma-Node*

Basic Noise Source
CAT. NO. 770

Available Noise
Accurate to ± 0.1 db

3 Noise Heads
Cover 1 kc to 1000 mc

Portable
Can be Operated from
117 V, 60 cycles or 24 V dc

Through refinement of a basic noise generation technique—thermal noise from a heated resistive element—the new Kay *Therma-Node* achieves high accuracy over an extremely wide range of frequencies. *Therma-Node's* resistive element, contained in the noise head, is heated to a normal 2200° K, generating adequate noise-power for accurate noise figure measurements to 10 db. Nominal fixed available noise temperature ranging between 2000 and 2400° K may be read directly on the panel meter to 2% accuracy. A single tuning element, contained in the noise head, provides a fixed range of 2 to 500 mc, and may be tuned to extend the range to 1000 mc. An optional, interchangeable head extends measurement down to 1 kc. Ambient termination is supplied. Both heads have output impedances of 50 ohms, unbalanced. Both heads can be used without connecting coaxial cables, thus eliminating cable errors.

A selectable-impedance noise head, covering the range .25 to 400 mc, and furnishing output impedances of 50, 100 and 200 ohms, balanced and unbalanced, is available as an accessory.

The inexpensive resistive element in the *Therma-Node* noise head has a life expectancy of 10,000 hours in either intermittent or continuous service. Because the few active components in the *Therma-Node* are solid state devices, its inherent stability results in long term accuracy and freedom from maintenance.

SPECIFICATIONS

STANDARD NOISE HEAD: (Head A furnished with **Therma-Node**), covers 2 to 1000 mc; output impedance 50 ohms, unbalanced. N type connectors.
Max. VSWR, variable tuned, 1.1 from 10 to 1000 mc.
Max. VSWR, fixed tuned, 1.1 from 10 to 100 mc; 1.2 from 6 to 300 mc; 1.4 from 4 to 400 mc; 2 from 2 to 500 mc.

INTERCHANGEABLE LOW FREQUENCY NOISE HEAD: (Head B), covers 1 kc to 400 mc; output impedance 50 ohms, unbalanced.
Max. VSWR 1.1 from 3 kc to 100 mc; 1.2 from 2 kc to 250 mc; 1.4 from 1 kc to 400 mc.

AMBIENT SOURCE PROBE for use with A and B Noise Heads:
Frequency range—0 to 1000 mc.
Output impedance—50 ohms, unbalanced.
Max. VSWR—1.1
Accuracy of indicated temperature—±1%.

SELECTABLE-IMPEDANCE NOISE HEAD: (Head C) covers 0.25 to 400 mc, balanced or unbalanced output. Selectable output impedances of 50, 100 and 200 ohms are provided.
Max. VSWR—1.1 from 1 to 75 mc; 1.2 from 0.5 to 100 mc; 1.4 from 0.25 to 400 mc.
Max. VSWR difference between ambient and hot source is 0.05 (hot and ambient sources contained in same probe).
Weight: 8 pounds in carrying case.
Dimensions: 11.5 x 8 x 4.75 inches.
Operates on 117 V, 60 cps, or 24 V dc
Price: $495.00, f.o.b. factory.
Low Frequency Noise Head (B): $125.00.
Selectable Impedance Head (C): $125.00.

OTHER KAY NOISE GENERATORS

Instrument & Cat. No.	Frequency Range (mc)	Noise Figure Range (db)	Output Impedance (ohms)	Price f.o.b. factory
Mega-Node 240-B	5-220	0-16 at 50 ohms 0-23.8 at 300 ohms	unbal.—50, 75, 150, 300, ∞ bal.—100, 150, 300, 600, ∞	$365.00
Mega-Node 175-A	50-500	0-19	balanced–300	$365.00
Mega-Node 403-A	3-500	0-19	unbalanced–50	$365.00
Mega-Node-Sr. 250-B	10-3000	0-20	unbalanced–50	$795.00
Radu-Node 600-A	5-400	0-23.8 depending on impedance	unbalanced as specified	$1495.00
	10-4000	0-20	unbal.–50, 75, 150, 300	$1395.00
	1120-26,500	15.28 or 15.8	waveguide	†
Micro-Node 1080-A	8000-12,400	0-15.8	waveguide	$795.00
*Microwave Mega-Nodes**	1120-26,500	15.28 or 15.8	waveguide	$175.00 to $595.00

† Price varies with **Microwave Mega-Node** discharge tube used as accessory.
* Ideally suited for noise figure measurement in radar communication.

WRITE FOR
KAY CATALOG 1959-A

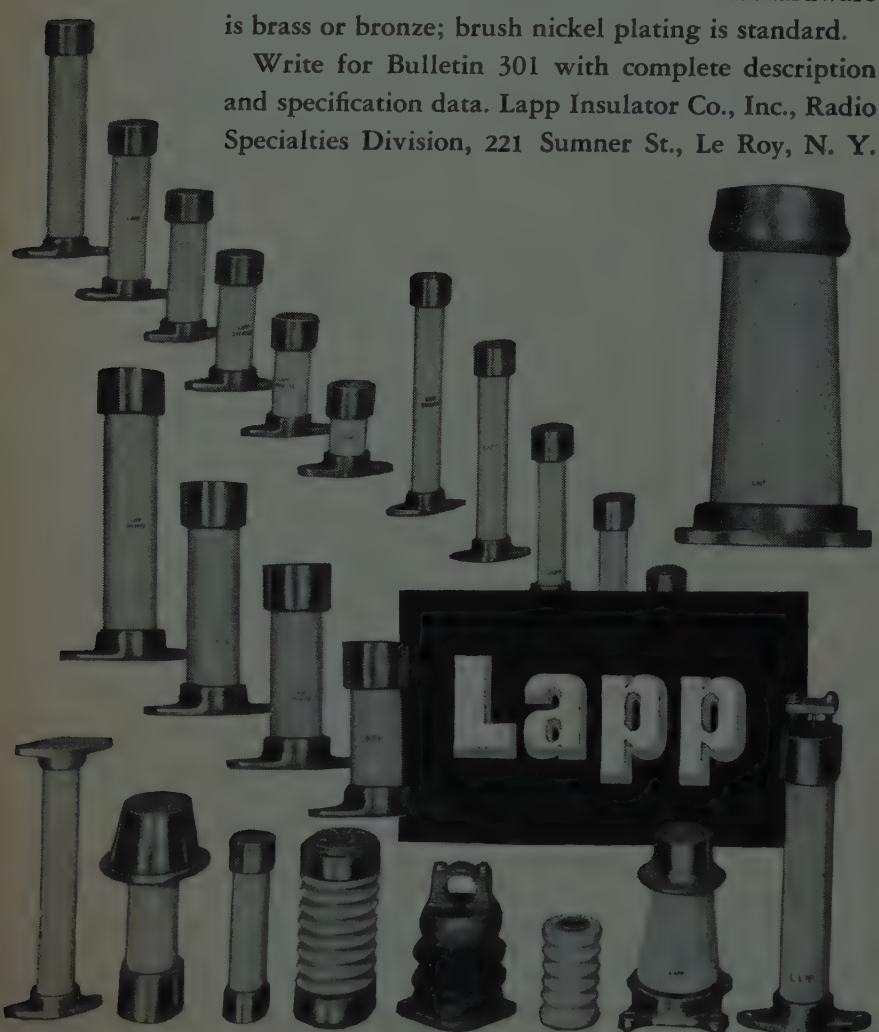
KAY ELECTRIC COMPANY
Dept. 1-12 Maple Avenue, Pine Brook, N.J. CApital 6-4000

LAPP STAND-OFF INSULATORS

FOR MODERATE OR HEAVY DUTY

For years, Lapp has been a major supplier of stand-off insulators to radio, television and electronics industries. Wide knowledge of electrical porcelain application, combined with excellent engineering and production facilities, makes possible design and manufacture of units to almost any performance specification. The insulators shown on this page are representative of catalog items—usually available from stock—and certain examples of special stand-offs. The ceramic used is the same porcelain and steatite of which larger Lapp radio and transmission insulators are made. Hardware is brass or bronze; brush nickel plating is standard.

Write for Bulletin 301 with complete description and specification data. Lapp Insulator Co., Inc., Radio Specialties Division, 221 Sumner St., Le Roy, N. Y.



Meetings with Exhibits

(Continued from page 8A)

August 23-26, 1960

WESCON, Western Electronic Show and Convention, Ambassador Hotel & Memorial Sports Arena, Los Angeles, Calif.

Exhibits: Mr. Don Larson, WESCON, 1435 LaCienega Blvd., Los Angeles, Calif.

September 19-21, 1960

National Symposium on Space Electronics & Telemetry, Shoreham Hotel, Washington, D.C.

Exhibits: John Leslie Whitlock Associates, 6044 Ninth St., North, Arlington 5, Va.

October 3-5, 1960

Sixth National Communications Symposium, Hotel Utica & Utica Memorial Auditorium, Utica, N.Y.

Exhibits: Mr. W. R. Roberts, 102 Fort Stanwix Park N., Rome, N.Y.

October 10-12, 1960

National Electronics Conference, Hotel Sherman, Chicago, Ill.

Exhibits: Mr. Arthur H. Streich, National Electronics Conference, 184 E. Randolph St., Chicago, Ill.

October 24-26, 1960

East Coast Aeronautical & Navigational Electronics Conference, Lord Baltimore Hotel & 7th Regiment Armory, Baltimore, Md.

Exhibits: Mr. R. L. Pigeon, Westinghouse Electric Corp., Air Arm Div., P.O. Box 746, Baltimore, Md.

November 14-16, 1960

Mid-America Electronics Convention (MAECON), Municipal Auditorium, Kansas City, Mo.

Exhibits: Mr. John V. Parks, Bendix Aviation Corp., P.O. Box 1159, Kansas City 41, Mo.

November 15-17, 1960

Northeast Electronics Research & Engineering Meeting (NEREM), Boston Commonwealth Armory, Boston, Mass.

Exhibits: Miss Shirley Whitcher, IRE Boston Office, 73 Tremont St., Boston, Mass.

December 1-2, 1960

PGVC Annual Meeting, Sheraton Hotel, Philadelphia, Pa.

Exhibits: Mr. E. B. Dunn, Atlantic Refining Co., 260 S. Broad St., Philadelphia 1, Pa.

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Note on Professional Group Meetings: Some of the Professional Groups conduct meetings at which there are exhibits. Working committeemen on these groups are asked to send advance data to this column for publicity information. You may address these notices to the Advertising Department and of course listings are free to IRE Professional Groups.

Ingenious, ultra-convenient...

NEW hp 196A OSCILLOSCOPE CAMERA

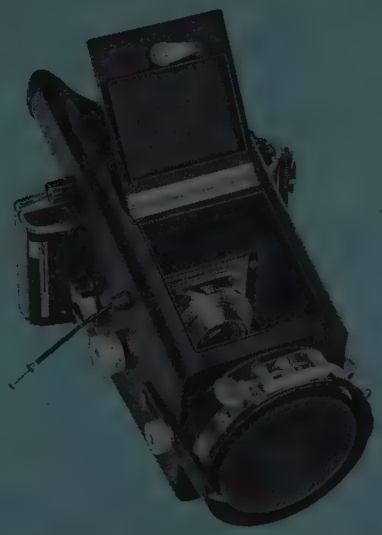
combines every feature you've wanted

FULL-SIZE, DISTORTION-FREE PICTURES. Full picture area may be scaled.

SHARP, CLEAR PICTURES, JUST LIKE CRT ITSELF. New f/1.9 lens has a flat field.

ADJUST CAMERA ON SCOPE. Not necessary to remove camera to set f-stop and shutter.

SIMPLE, ONE-HAND MOUNTING. Easy clamp mounts camera on scope with "quick-lock" tab.



MULTIPLE EXPOSURES ARE EASY. With one hand, move lens through 11 detented positions.

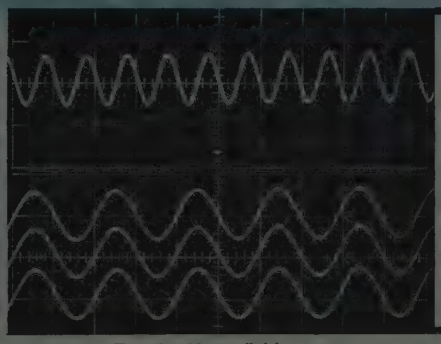
EASY TAB PULLING. Polaroid® Land Camera back is securely fastened.

INSURED AGAINST LIGHT LEAKS; uses professional camera bellows.

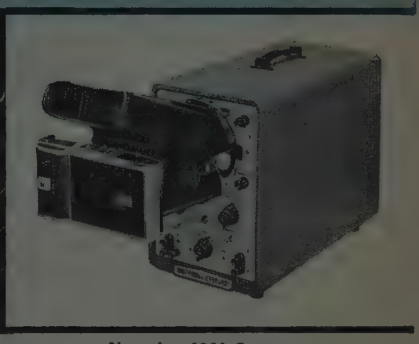
WEAR GLASSES? Keep 'em on while viewing image with both eyes.

10 CM GRATICULE FILLS FULL FILM AREA!

Up to 11 equally spaced exposures available



Two 4 x 10 cm field exposures. No overlapping



New -hp- 196A Camera on -hp- 120A Oscilloscope

The new hp 196A Oscilloscope Camera is the most convenient means yet devised for recording oscilloscope traces. Operation is extremely simple and swift; loss of film from light leakage is eliminated; mounting and unmounting takes just seconds; the entire unit is light weight, rugged, compact, yet a precision instrument in every respect.

Check the specifications below, and ask your hp representative for demonstration on your oscilloscope.

Object/Image Ratio:	1 to 0.9. (Adjustable to 1:1 ratio)	**Film:**	Polaroid ® Land types 42, 44, 46, 46-L.
Lens:	Wollensak 3" (75 mm) f/1.9 Oscillo-Raptar	**Size:**	13½" long, 9¼" high, 10" wide Weight 9 lbs.
Shutter:	Alphax #3. Time, Bulb, 1/100, 1/50, 1/25, 1/10, 1/5, 1/2, 1 second	**Accessories Available:**	Carrying case, Tektronix adapter
Print Size:	2-7/8" x 3-13/16"	**Price:**	$425.00

Data subject to change without notice. Prices f.o.b. factory.

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Where can you use this versatile HI-SHOCK SWITCH?

Military missiles, mines, shipboard antennas, or industrial and commercial equipment wherever rigorous vibration, shock or constant acceleration is present, this new Hi-Shock Switch offers distinct advantages.

Engineered and custom-packaged. The Hi-Shock Switch can be used for remote power switching (mounted directly on moving members)... changeover from primary to auxiliary power source, AC or DC... rapid stepping of power distribution.

Hermetically Sealed. Use in remotely controlled, power operated units or as a sequence exciter for auxiliary prime movers.

100% Rotary Action, Counter Balanced. The actuator, a rotary solenoid, is counter balanced in all axes. Standard coil voltages range from 6 to 48 volts, but other ranges can be furnished as required. High-speed stepping—30 per second—is one feature; higher speeds are available for specific designs.

Positive Stopping, Positive Locking. The ratchet mechanism prevents overshooting of the switch contacts—which will not move except during actual stepping. This mechanism is simple, reliable, virtually fatigue-proof.

Knife-Edge Contacts. On rotary switch contacts are strong and simple, provide positive connections to prevent chattering under acceleration and other vibration-producting conditions.

Environmental Ratings. The Hi-Shock Switch withstands non-operating impacts of 1000 g for one millisecond parallel to its rotating axis, and 100 g for one millisecond perpendicular to its rotating axis. The stepping switch operates under vibration, in three mutually perpendicular axis, of 0.5″ double amplitude 5—17.5 cps., and 10 g 17.5—2000 cps. Constant operating acceleration may be as high as 100 g, in axis parallel to rotation. Operating temperature range may exceed —65°F. and +165°F., and could be extended under special conditions.

Other models also developed with varying configurations and contact arrangements with higher current rating. Write for complete details. *Hi-Shock, Singer Military Products Division, Singer-Bridgeport, 915 Pembroke Street, Bridgeport 8, Conn.*

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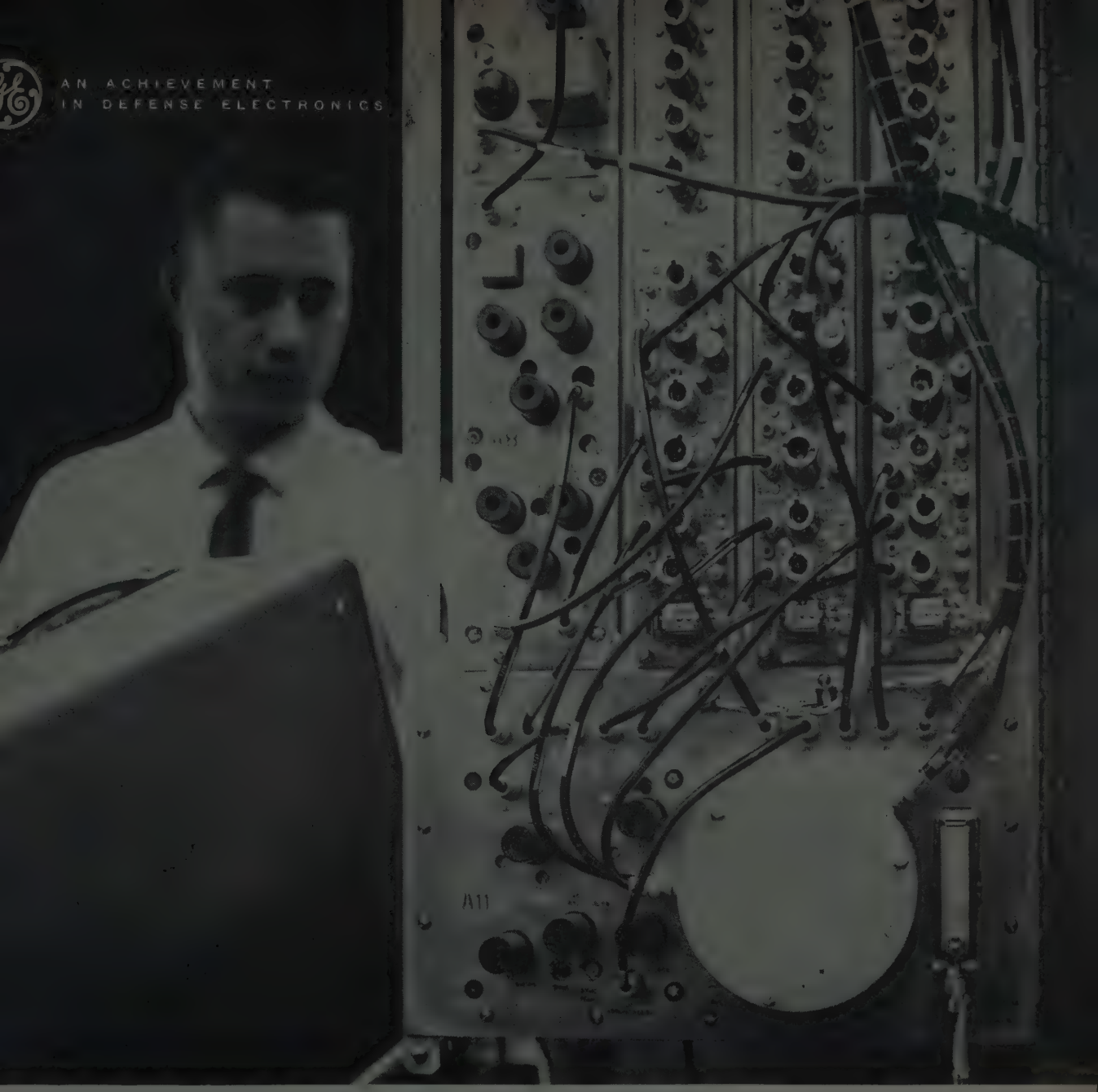
915 Pembroke Street Bridgeport 8, Conn.



NEW SONAR SIGNAL PROCESSOR DOES WORK OF 1,000 UNITS

The first sonar signal processors to utilize time compression are being produced by General Electric. These new processors were developed in cooperation with the United States Navy. Extracting only critical bits of transmitted and received signals in series, one unit can perform as many correlating operations on a continuous signal—in the same time—as a parallel processor with thousands of units.

Excellent improvement in signal-to-noise ratio also makes these new processors effective against background levels which have formerly made certain signals undetectable by any other practical means. The new equipment is also designed to handle signals from more than one transducer.

This advance in sonar signal processing is typical of General Electric's many achievements in defense electronics. 227-3

Progress Is Our Most Important Product

GENERAL ELECTRIC

DEFENSE ELECTRONICS DIVISION • HEAVY MILITARY ELECTRONICS DEPT. • SYRACUSE, N. Y.

Calendar of Coming Events and Authors' Deadlines*

1959

Eastern Joint Comp. Conf., Hotel Statler, Boston, Mass., Dec. 1–3.

4th Midwest Symp. on Circuit Theory, Brooks Mem. Union, Marquette Univ., Milwaukee, Wis., Dec. 1–2.

PGVC Annual Meeting, St. Petersburg, Fla., Dec. 3–4.

Institute of Mathematical Statistics Mtg., Washington, D.C., Dec. 27–30.

1960

6th Natl. Symp. on Reliability and Quality Control, Statler-Hilton Hotel, Wash., D.C., Jan. 11–13.

PGMIL Winter Mtg., Biltmore Hotel, Los Angeles, Calif., Feb. 3–5.

1960 Solid State Circuits, Conf., Sheraton Hotel, Phila., Pa., Feb. 10–12.

IRE National Conv., N. Y. Coliseum and Waldorf-Astoria Hotel, New York, N. Y., Mar. 21–24.

First Natl. Symp. on Human Factors in Electronics, New York, N. Y., Mar. 24–25.

Scintillation Counter Symp., Washington, D.C., Mar.

6th Nuclear Congress, N. Y. Coliseum, New York, N. Y., Apr. 4–8.

Conf. on Automatic Tech., Sheraton-Cleveland Hotel, Cleve., Ohio, Apr. 18–19.

SWIRECO (Southwestern Regional Conference), Houston, Texas, Apr. 20–22.

Natl. Aeronautical Electronics Conf., Dayton, Ohio, May 2–4.

Western Joint Computer Conf., San Francisco, Calif, May 2–6.

PGMTT Natl. Symp., San Diego, Calif., May 9–11. (DL*: Jan. 15, D.B. Medved, CONVAIR, Div. of Gen. Dynamics Corp., Mail Zone 6-172, San Diego, Calif.

Electronic Components Conf., Washington, D. C., May 10–12.

7th Reg. Tech. Conf. & Trade Show, Olympic Hotel, Seattle, Wash., May 23–25.

Natl. Conv. on Mil. Elec., Sheraton Park Hotel, Washington, D. C., June 27–29.

* DL = Deadline for submitting abstracts.

(Continued on page 15A)

PGMTT Symposium Calls for Papers

The 1960 annual symposium of the PGMTT will be held May 9–11 at the Hotel del Coronado, Coronado, Calif. Papers in the field of microwave components, systems and physics, are being solicited for presentation at the meeting. One hundred word abstracts in triplicate and 500 word summaries in triplicate should be submitted before January 15, 1960 to Dr. D. B. Medved, Chairman, Technical Program Committee, 1960 PGMTT Symposium, CONVAIR, Div. of General Dynamics Corp., Mail Zone 6-172, San Diego 12, Calif.

All papers are to be submitted in English. Authors should advise the Technical Program Committee if any paper will have been presented elsewhere or published prior to the symposium.

D. B. Sinclair Attends Hungarian Colloquium

Donald B. Sinclair attended a Colloquium on Microwave Communication sponsored by the Hungarian Academy of Sciences, held in Budapest, Hungary, November 10–13, 1959, as a representative of the IRE, of which he is past president, and is now a vice president and director. He is chief engineer, vice president and director of the General Radio Co., West Concord, Mass.

Last year he was a delegate to a similar meeting held in the USSR at which representatives from six Western nations and six Iron Curtain countries were invited guests.

Preliminary information on the Budapest meeting indicated that special consideration would be given to system analysis (with emphasis on long-distance transmission), microwave electronics (including circuits and antennas) and general electronic circuitry. The papers are delivered in Hungarian, English, German and Russian, and provision is made for simultaneous translation so that all representatives can follow each talk as delivered.

H. P. Kalmus Awarded Prize at Army Symposium

Henry P. Kalmus (A'39–SM'45–F'56), Associate Director for Advanced Research at the Diamond Ordnance Fuze Laboratories, Washington, D. C., was awarded a certificate of commendation and a cash prize of $500.00 for his first place entry in in the field of electronics at the National Military Science Symposium. The meeting was conducted by the Department of the Army, at West Point, N. Y. The award-winning paper concerned Mr. Kalmus' invention entitled "Cigarette Fuze."

PGHFE Will Conduct First Annual Symposium

The IRE Professional Group on Human Factors in Electronics will hold its first annual symposium in New York, N. Y., the evening of March 24 and all day March 25, 1960.

Those interested in presenting papers or in suggesting symposia should correspond as soon as possible with either R. R. Riesz, Chairman of the Papers Procurement Committee, c/o Bell Telephone Labs., Murray Hill, N. J.; or J. E. Karlin, Chairman of the Meetings Committee, at the same address.

Chairman George E. Hagerty (left) presenting the Scott Helt Award of the PG on Broadcasting to Professor Alfred H. La Grone of the University of Texas. The plaque was awarded at the Ninth Annual Broadcast Symposium.

A. J. Buxton and M. O. Felix Receive NEC Annual Award

A. J. Buxton and M. O. Felix (SM'55), both of Canadian Westinghouse Company, Ltd., received the National Electronics Conference Award for their joint paper, "The Performance of FM Scatter Systems Using Frequency Compression." The NEC award, consisting of $500 and certificates, was presented to them on October 12, 1959, during the 15th Annual NEC. The paper was adjudged the best in terms of scholarship, originality, significance and clarity among the 100 papers presented October 13–15, 1958, at the 14th Annual NEC.

Mr. Buxton and Mr. Felix are co-inventors of a method to improve scatter communications systems by significantly reducing undesirable noise. The scatter system is used for long-range, beyond-the-horizon transmission of voice, television, teletype, facsimile, telemetering and data signals over hops of 100 to 200 miles. They are currently working on scatter projects for the RCAF, U. S. Air Force, and Supreme Headquarters Allied Powers in Europe.

J. J. Lamb Receives ARRL Merit Award

The Merit Award of the American Radio Relay League for 1959 went to James J. Lamb (A'28–SM'48–F'54) for his significant contributions to the welfare of amateur radio. He was presented the award at the New England Division Convention of the League, at Hartford, Conn.

The plaque is inscribed: "For his contribution to amateur communication techniques, especially in the development of methods for achieving high selectivity and noise reduction in radio reception."

The work which the ARRL Merit Award commemorates was done during his tenure as technical editor of the League's monthly publication, QST, and exercised a profound influence on the course of development of radio receivers for communications applications. The Lamb crystal filter, an integral part of the receiving system developed by him, has been a standard feature of communications receivers for more than 25 years.

Born in Michigan, N. D., Mr. Lamb received the E.E. degree from Catholic University of America, Washington, D. C., in 1922, operated a standard broadcast station in Grand Forks, N. D. in the early 1920's and joined the technical staff of the ARRL in 1928. He was technical editor from 1929 until 1939 and in 1940 was a research engineer with the League working on special projects. In 1941, he was chosen to organize and head the newly-formed Electronic Division of Remington-Rand, Inc. (now Sperry-Rand) to develop military airborne television equipment. In recent years he has specialized in digital data developments, and in 1959 became an independent consulting engineer, concentrating on communications and industrial electronics.

Three Honored in Italy for Outstanding Achievement in Telecommunications

The Christopher Columbus International Award for outstanding achievement in telecommunications was presented in Genoa, Italy, on October 12, to Brig. General David Sarnoff, Chairman of the Board of RCA; Dr. E. W. Engstrom, Senior Executive Vice President of RCA; and Dr. V. K. Zworykin, Honorary Vice President of RCA.

The presentation was made by President Giovanni Gronchi of Italy at the closing session of the Seventh International Congress on Communications. General Sarnoff and Dr. Engstrom received the award, which consists of a purse and gold medal, in person.

James J. Lamb (*left*) receiving the ARRL Merit Award for 1959 from G. L. Dosland, President of the League.

Calendar of Coming Events and Authors' Deadlines*

(Continued from page 14A)

Cong. Intl. Federation of Automatic Control, Moscow, USSR, June 25–July 9.

WESCON, Los Angeles Mem. Sports Arena, Los Angeles, Calif., Aug. 23–26.

Space Electronics and Telemetry Conv. and Symp., Shoreham Hotel, Washington D.C., Sept. 19–22.

Industrial Elec. Symp., Sept. 21–22.

Sixth Natl. Communications Symp., Hotel Utica and Utica Memorial Aud., Utica, N. Y., Oct. 3–5.

Natl. Elec. Conf., Chicago, Ill., Oct. 10–12.

East Coast Conf. on Aero & Nav. Elec., Baltimore, Md., Oct. 24–26.

Electron Devices Mtg., Hotel Shoreham, Washington, D. C., Oct. 27–29.

Radio Fall Mtg., Hotel Syracuse, Syracuse, N. Y., Oct. 31, Nov. 1–2.

Mid-Amer. Elec. Conv., Kansas City, Mo., Nov. 14–16.

1960 NEREM (Northeast Electronics Res. & Engrg. Mtg.), Boston, Mass., Nov. 15–17.

13th Ann. Conf. on Elec. Tech. in Med. and Bio., Washington, D. C., Nov.

PGVC Ann. Mtg., Sheraton Hotel, Philadelphia, Pa., Dec. 1–2.

Eastern Joint Computer Conf., New Yorker Hotel, New York, N.Y., Dec.

1961

IRE National Conv., N.Y. Coliseum and Waldorf-Astoria Hotel, New York, N.Y., Mar. 20–23.

Electronic Computer Conf., West Coast, May 9–11.

WESCON, San Francisco, Calif., Aug. 22–25.

Natl. Symp. on Space Elec. and Telemetry, Sept.

Industrial Elec. Symp., Sept. 20–21.

National Elec. Conf., Chicago, Ill., Oct. 9–11.

1961 NEREM (Northeast Electronics Res. & Engrg. Mtg.), Nov. 14–16.

1961 Electron Devices Mtg., Shoreham Hotel, Washington, D. C., Nov. 20–21.

Mid-America Elec. Conv. (MAECON), Kansas City, Mo., Nov. 14–16.

Eastern Joint Computer Conf., Sheraton Park Hotel, Washington, D. C., Dec.

* DL = Deadline for submitting ab-

Current IRE Standards

Please order by number from IRE Headquarters, 1 E. 79 St., N. Y. 21, N. Y. A 20 per cent discount will be allowed on order for 100 or more copies mailed to one address.

Standard	*Cost*
48 IRE 2., 11., 15.S1 Standards on Antennas, Modulation Systems, and Transmitters: Definitions of Terms, 1948	**$0.75**
53 IRE 2.S1 Standards on Antennas and Waveguides: Definitions of Terms, 1953. Adopted by ASA. (ASA C16.21-1954.) Reprinted from the December, 1953, PROCEEDINGS	**$0.75**
55 IRE 2.S1 Standards on Antennas and Waveguides: Definitions for Waveguide Components, 1955. Reprinted from the September, 1955, PROCEEDINGS	**$0.25**
59 IRE 2.S1 Standards on Antennas and Waveguides: Waveguide and Component Measurements, 1959 Reprinted from the April, 1959, PROCEEDINGS	**$0.75**
48 IRE 2.S2 Standards on Antennas: Methods of Testing, 1948. Adopted by ASA. (ASA C16.11-1949.)	**$0.75**
54 IRE 3.S1 Standards on Audio Techniques: Definitions of Terms, 1954. Reprinted from the July, 1954, PROCEEDINGS	**$0.50**
56 IRE 3.S1 Standards on Audio Systems and Components: Methods of Measurement of Gain, Amplification, Loss, Attenuation and Amplitude-Frequency-Response, 1956. Adopted by ASA. (ASA C16.29-1957.) Reprinted from the May, 1956, PROCEEDINGS	**$0.80**
58 IRE 3.S1 Standards on Audio Techniques: Definitions of Terms, 1958. Reprinted from the December, 1958, PROCEEDINGS	**$0.60**
53 IRE 3.S2 Standards on American Recommended Practice for Volume Measurements of Electrical Speech and Program Waves, 1953. Adopted by ASA. (ASA C16.5-1954.) Reprinted from the May, 1954, PROCEEDINGS	**$0.50**
50 IRE 4.S1 Standards on Circuits: Definitions of Terms in Network Topology, 1950. Reprinted from the January, 1951, PROCEEDINGS	**$0.50**
53 IRE 4.S1 Standards on Circuits: Definitions of Terms in the Field of Linear Varying Parameter and Nonlinear Circuits, 1953. Reprinted from the March, 1954, PROCEEDINGS	**$0.25**
51 IRE 6.S1 Standards on Electroacoustics: Definitions of Terms, 1951. Reprinted from the May, 1951, PROCEEDINGS	**$1.00**
52 IRE 7.S1 Standards on Magnetrons: Definitions of Terms, 1952. Reprinted from the May, 1952, PROCEEDINGS	**$0.25**
54 IRE 7.S1 Standards on Electron Devices: Definitions of Terms Related to Phototubes, 1954. Reprinted from the August, 1954, PROCEEDINGS	**$0.25**
56 IRE 7.S1 Standards on Electron Devices: Definitions of Terms, Related to Microwave Tubes (Klystrons, Magnetrons, and Traveling Wave Tubes), 1956. Reprinted from the March, 1956, PROCEEDINGS	**$0.50**
57 IRE 7.S1 Standards on Electron Tubes: Physical Electronics Definitions, 1957. Reprinted from the January, 1957, PROCEEDINGS	**$0.50**
50 IRE 7.S2 Standards on Electron Tubes: Methods of Testing, 1950. Part I Reprinted from August, 1950, PROCEEDINGS. Part II Reprinted from September, 1950, PROCEEDINGS	**$1.25**
52 IRE 7.S2 Standards on Gas-Filled Radiation Counter Tubes: Methods of Testing, 1952. Adopted by ASA. (ASA C60.11-1954.) Reprinted from the August, 1952, PROCEEDINGS	**$0.75**
54 IRE 7.S2 Standards on Electron Devices: Definitions of Semiconductor Terms, 1954. Reprinted from the October, 1954, PROCEEDINGS	**$0.50**
56 IRE 7.S2 Standards on Electron Devices: Definitions of Terms Related to Storage Tubes, 1956. Reprinted from the April, 1956, PROCEEDINGS	**$0.25**
57 IRE 7.S2 Standards on Electron Tubes: Definitions of Terms, 1957. Reprinted from the July, 1957, PROCEEDINGS	**$1.00**
52 IRE 7.S3 Standards on Gas-Filled Radiation Counter Tubes: Definitions of Terms, 1952. Reprinted from the August, 1952, PROCEEDINGS	**$0.50**
56 IRE 7.S3 Standards on Electron Tubes: TR and ATR Tube Definitions, 1956. Reprinted from the August, 1956, PROCEEDINGS	**$0.50**
56 IRE 8.S1 Standards on Electronic Computers: Definitions of Terms, 1956. Reprinted from the September, 1956, PROCEEDINGS	**$0.60**
59 IRE 8.S1 Standards on Static Magnetic Storage: Definition of Terms, 1959. Reprinted from the March, 1959, PROCEEDINGS	**$0.50**
43 IRE 9.S1 Standards on Facsimile: Temporary Test Standards, 1943	**$0.20**
56 IRE 9.S1 Standards on Facsimile: Definitions of Terms, 1956. Adopted by ASA. (ASA C16.30-1957.) Reprinted from the June, 1956, PROCEEDINGS	**$0.60**
55 IRE 10.S1 Standards on Industrial Electronics: Definitions of Industrial Electronics Terms, 1955. Reprinted from the September, 1955, PROCEEDINGS	**$0.50**
53 IRE 11.S1 Standards on Modulation Systems: Definitions of Terms, 1953. Reprinted from the May, 1953, PROCEEDINGS	**$0.50**
58 IRE 11.S1 Standards on Information Theory: Definitions of Terms, 1958. Reprinted from the September, 1958, PROCEEDINGS	**$0.50**
54 IRE 12.S1 Standards on Radio Aids to Navigation: Definitions of Terms, 1954. Adopted by ASA. (ASA C16.26-1955.) Reprinted from the February, 1955, PROCEEDINGS	**$1.00**
59 IRE 12.S1 Standards on Navigation Aids: Direction Finder Measurement, 1959. Reprinted from the August, 1959, PROCEEDINGS	**$1.00**

(Continued on page 18A)

MIL-E-CON Issues Call for Papers

The 4th National Convention on Military Electronics—1960 (MIL-E-CON) will be held at the Sheraton-Park Hotel, Washington, D. C., on June 27–29, 1960, under the sponsorship of the Professional Group on Military Electronics. Robert H. Cranshaw, Manager, Advanced Space Projects, General Electric Company, Utica, N. Y., is Convention President for MIL-E-CON.

Papers presenting original work in military electronics are invited for this meeting. Suggested topics include, but are not limited to the following: Current Problems of Space Technology, Space Electronics, Ranging and Tracking, Electronic Propulsion, Data Handling Systems, Guidance and Control, Inertial Systems, Reconnaissance Systems, Communication Systems, Operational Analysis, and Reliability.

The technical program will include both classified (limited to confidential) and unclassified sessions, with the Air Research and Development Command sponsoring the classified sessions. An unclassified and bound *Proceedings* of the convention will be available at the meeting.

Prospective authors are requested to furnish the following information, *not later than February 1, 1960;* Three copies of a 250-word unclassified abstract of the proposed paper, plus the name and position of the author and the name and address of his company or organization. Each author must obtain the appropriate military and company clearances for his abstract.

Send abstracts to: Dr. Craig M. Cranshaw, Dept. of Army, Office of the Chief Signal Officer, R & D Div., SIGRD-2, Washington 25, D. C.

Army MARS Announces December Schedule

The First U. S. Army Military Affiliate Radio System (MARS) Single Side Band Technical Net has scheduled five speakers for December. The net can be heard each Wednesday at 9 P.M. EST on 4030 kilocycles upper sideband. The schedule includes:

December 2—"Technical Aspects of Satellite Communications," L. Smilen, Res. Associate, Microwave Res. Inst., Brooklyn Polytechnical Institute.

December 9—"The Trans-Atlantic Submarine Telephone Cable," H. West, Plant Design Engineer, Long Lines Dept., American Telephone & Telegraph Co.

December 16—"Determination of Percent Success Expectable in High Frequency Radio Transmission," G. Krause, Project Engineer, Analysis Engineering Div., U. S. Army Signal Radio Propagation Agency, Fort Monmouth.

December 23—"FM Forward Scatter Tropospheric Communications Systems," J. Lesmez, Project Engineer, Radio Engineering Labs. Inc.

December 30—"Coaxial Cable," M. Ferber, Sales Engineer, Times Wire & Cable Co.

George at the Forge

The day the mobile radar was delivered to Washington at Valley Forge, it was so cold a man's shadow froze to the ground. Nevertheless, the Father of his Country managed to work up a good head of steam when he saw the unit.

*"Idiots!" he stormed. "Why do they send me radar when we need food and shelter and clothing? What good is it? Does it have Bomac tubes?"**

"No sir," his orderly shivered. "It doesn't seem to have any tubes at all. But it might make a nice warm fire."

"I was thinking the same," Washington said. And, without another word, he went and got a little hatchet and chopped and chopped. The wind blew and the chips flew. Soon, the installation was reduced to kindling.

"That's more like it," the General said when he was done. "Now, if someone will hand me a match . . ."

But he never finished the sentence. The ice on which he was standing suddenly gave way, and he disappeared into the frigid water.

"General, general are you all right?" the orderly asked as he fished him out.

"I'm afraid so," Washington said. "But you'd better put a sign here to warn the others."

So, that was why the famous sign was put up — the sign you can see today when you visit Valley Forge. You know the one.

It reads "George Washington slipped here."

No. 17 of a series . . . BOMAC LOOKS AT RADAR THROUGH THE AGES

* Bomac tubes are used in the latest radar equipment.

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The Executive Committee of the Benelux Section at the Rotterdam meeting—Mr. C. B. Broersma, Membership; Dr. V. Belevitch, Vice-Chairman; Mr. B. B. Barrow, Secretary-Treasurer; Mr. H. Rinia, Chairman; Mr. J. M. L. Janssen, Meetings and Papers; and Dr. H. P. Williams, Publicity.

Current IRE Standards

Please order by number from IRE Headquarters, 1 E. 79 St., N. Y. 21, N. Y. A 20 per cent discount will be allowed on order for 100 or more copies mailed to one address.

	Standard	*Cost*
49 IRE 14.S1	**Standards on Piezoelectric Crystals, 1949. Adopted by ASA. (ASA C83.3-1951, R 1954.)** Reprinted from the December, 1949, PROCEEDINGS	$0.80
57 IRE 14.S1	**Standards on Piezoelectric Crystals—The Piezoelectric Vibrator: Definitions and Methods of Measurement, 1957.** Reprinted from the March, 1957, PROCEEDINGS	$0.60
58 IRE 14.S1	**Standards on Piezoelectric Crystals: Determination of the Elastic, Piezoelectric, and Dielectric Constants—The Electromechanical Coupling Factor, 1958.** Reprinted from the April, 1958, PROCEEDINGS	$0.75
55 IRE 15.S1	**Standards on Pulses: Methods of Measurements of Pulse Quantities, 1955. Adopted by ASA. (ASA C16.28-1956.)** Reprinted from the November, 1955, PROCEEDINGS	$0.60
58 IRE 15.	**TRI IRE Technical Committee Report: Methods for Testing Radiotelegraph Transmitters (Below 50 MC).** Reprinted from the January, 1959, PROCEEDINGS	$0.60
49 IRE 16.S1	**Standards on Railroad and Vehicular Communications: Methods of Testing, 1949.** Reprinted from the December, 1949, PROCEEDINGS	$0.50
47 IRE 17.S1	**Standards on Radio Receivers: Methods of Testing Frequency-Modulation Broadcast Receivers, 1947. Adopted by ASA. (ASA C16.12-1949.)**	$0.50
48 IRE 17.S1	**Standards on Radio Receivers: Methods of Testing Amplitude-Modulation Broadcast Receivers, 1948**	$1.00
49 IRE 17.S1	**Tests for Effects of Mistuning and for Downward Modulation. 1949 Supplement to 47 IRE 17.S1.** Reprinted from the December, 1949, PROCEEDINGS	$0.25
51 IRE 17.S1	**Standards on Radio Receivers: Open Field Method of Measurement of Spurious Radiation from Frequency Modulation and Television Broadcast Receivers, 1951.** Reprinted from the July, 1951, PROCEEDINGS	$0.50
52 IRE 17.S1	**Standards on Receivers: Definitions of Terms, 1952.** Reprinted from the December, 1952, PROCEEDINGS	$0.60
54 IRE 17.S1	**Standards on Receivers: Methods of Measurement of Interference Output of Television Receivers in the Range of 300 to 10,000 KC, 1954. Adopted by ASA. (ASA C16.25-1955.)** Reprinted from the September, 1954, PROCEEDINGS	$0.60
55 IRE 17.S1	**Standards on Radio Receivers: Method of Testing Receivers Employing Ferrite Core Loop Antennas, 1955.** Reprinted from the September, 1955, PROCEEDINGS	$0.50
53 IRE 19.S1	**Standards on Sound Recording and Reproducing: Methods of Measurement of Noise, 1953.** Reprinted from the April, 1953, PROCEEDINGS	$0.50
58 IRE 19.S1	**Standards on Recording and Reproducing: Methods of Calibration of Mechanically-Recorded Lateral Frequency Records, 1958.** Reprinted from the December, 1958, PROCEEDINGS	$0.60
53 IRE 19.S2	**Standards on Sound Recording and Reproducing: Methods for Determining Flutter Content, 1953. Adopted by ASA. (ASA Z57.1-1954.)** Reprinted from the March, 1954, PROCEEDINGS	$0.75
51 IRE 20.S1	**Standards on Pulses: Definitions of Terms—Part I, 1951.** Reprinted from the June, 1951, PROCEEDINGS	$0.50
52 IRE 20.S1	**Standards on Pulses: Definitions of Terms—Part II, 1952.** Reprinted from the May, 1952, PROCEEDINGS	$0.50
58 IRE 20.S1	**Index to IRE Standards on Definitions of Terms, 1942–1957.** Reprinted from the February, 1958, PROCEEDINGS	$1.00
51 IRE 20.S2	**Standards on Transducers: Definitions of Terms, 1951.** Reprinted from the August, 1951, PROCEEDINGS	$0.50
51 IRE 21.S1	**Standards on Abbreviations of Radio-Electronic Terms, 1951.** Reprinted from the April, 1951, PROCEEDINGS	$0.50
54 IRE 21.S1	**Standards on Graphical Symbols for Electrical Diagrams, 1954.** Reprinted from the June, 1954, PROCEEDINGS	$1.25

(*Continued on page 20A*)

Benelux Section Holds Initial Meeting

On October 3, 1959, the newly-formed Benelux Section of the IRE held its first meeting at the Rotterdam Offices of Radio-Holland, N. V. Talks were given on the radio and navigational equipment of the new *S. S. Rotterdam* by C. B. Broersma, Managing Director of Radio-Holland, H. T. Hylkema, Chief Engineer of Radio-Holland, and A. Webster, Assistant Nautical Superintendent of the Holland-America Line. The meeting was opened by the Section Chairman, H. Rinia, Director of Research at Philips Laboratories in Eindhoven.

Radio-Holland was host during the lunch which followed, at which Dr. L. V. Berkner, President of URSI and a Director of the IRE, presented the good wishes of the Board of Directors and emphasized the international character of the Institute and its interest in promoting contact among radio engineers from all lands. Mr. Rinia reported that Dr. Balthasar van der Pol was prevented from attending by his serious illness, and the group sent a telegram of greetings which was the last message of the IRE to one of its most respected and senior Fellows.

In the afternoon the party went aboard the Rotterdam, new flagship of the Holland-America Line, where they visited the radio station and the navigational equipment on the bridge. Many other parts of this fascinating ship were also visited, so that the occasion was a memorable one for the 77 members and guests who attended the meeting.

NYU Institute Offers Temporary Memberships

The Institute of Mathematical Sciences at New York University, N. Y., is offering temporary memberships to mathematicians and other scientists holding the Ph.D. degree who intend to study and do research in the fields in which the Institute is particularly active. These fields include Functional Analysis, Function Theory, Differential Equations, Mathematical Physics, Fluid Dynamics and Magnetohydrodynamics, Electromagnetic Theory and Numerical Analysis and Digital Computing.

The temporary membership program is designed primarily to alleviate the present critical shortage of scientists trained in mathematical physics, applied mathematics, and mathematical analysis. The program is being supported by the National Science Foundation and also by funds contributed by industrial firms to New York University.

Temporary members may participate freely in the research projects, the advanced graduate courses, and the research seminars of the Institute, and they will have the opportunity of using the computational facilities. They will receive a grant commensurate with their status.

Temporary memberships are awarded for one year, but may be renewed in special cases. Appropriate arrangements can be made for applicants who expect to be on leave of absence from their institutions.

Requests for information and for application blanks should be addressed to the Membership Committee, Institute of Mathematical Sciences, 25 Waverly Place, New York 3, N. Y.

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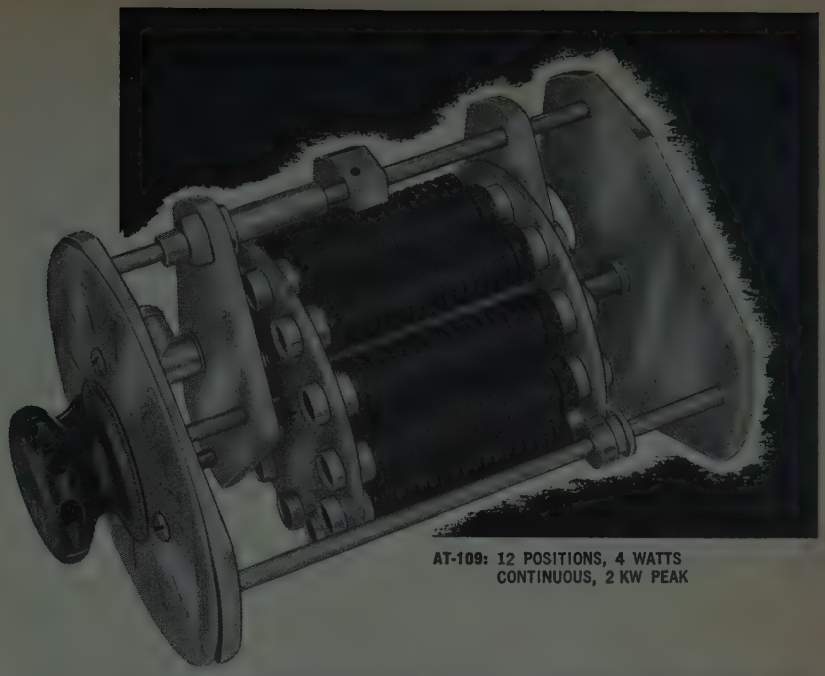
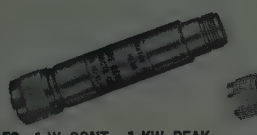


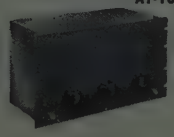
AT-109: 12 POSITIONS, 4 WATTS CONTINUOUS, 2 KW PEAK

EMPIRE COAXIAL ATTENUATORS

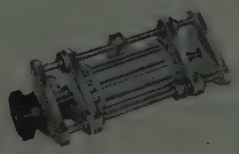


AT-50: 1 W CONT., 1 KW PEAK
AT-60: 2 W CONT., 2 KW PEAK

AT-75: 4 W CONT., 2 KW PEAK



AT-106: ATTENUATOR PANEL FOR VALUES UP TO 120 DB USING COMBINATIONS OF STEP ATTENUATORS.



AT-103: 6 POSITIONS, 1 WATT CONTINUOUS, 1 KW PEAK

AT-108: 6 POSITIONS, 4 WATT CONTINUOUS, 2 KW PEAK

AT-104: 12 POSITIONS, 1 WATT CONTINUOUS, 1 KW PEAK

Rated up to 4 Watts

Empire attenuators have been designed and constructed for the reliable performance so essential to modern, complex systems. Their rugged construction ...conservative power ratings for CW and pulse operation...and exclusive deposited carbon precision resistors...enable them to satisfy your microwave attenuation requirements.

Resistive coaxial networks furnished for frequencies up to 4000 MC, higher on special order. Low VSWR and high accuracy are inherent features. Attenuation values up to 60 DB are obtained in individual pads, rated up to 4 watts continuous and 2 KW peak (AT-75) or as six and twelve position step attenuators (AT-108, AT-109). With two or three attenuators connected in series, values up to 120 DB can be obtained.

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E. W. Pappenfus (*standing*), toastmaster at the banquet of the Cedar Rapids Symposium on Antennas and Propagation, with (*seated left to right*) E. L. Martin, Symposium Chairman, Dr. R. C. McCreary, Chairman of the Cedar Rapids Section, and Dr. Ernst Weber, President of the IRE.

CURRENT IRE STANDARDS

Please order by number from IRE Headquarters, 1 E. 79 St., N. Y. 21, N. Y. A 20 per cent discount will be allowed on order for 100 or more copies mailed to one address.

Standard	*Cost*
57 IRE 21.S1 Standards on Letter Symbols and Mathematical Signs, 1948. (Reprinted 1957.) Reprinted from the August, 1957, PROCEEDINGS	**$0.60**
57 IRE 21.S2 Standards on Reference Designations for Electrical and Electronic Equipment, 1957. Reprinted from the November, 1957, PROCEEDINGS	**$0.70**
57 IRE 21.S3 Standards on Graphical Symbols for Semiconductor Devices, 1957. Reprinted from the December, 1957, PROCEEDINGS	**$0.60**
48 IRE 22.S1 Standards on Television: Methods of Testing Television Receivers, 1948. Adopted by ASA. (ASA C16.13-1949.)	**$1.00**
55 IRE 22.S1 Standards on Television: Definitions of Color Terms, 1955. Reprinted from the June, 1955, PROCEEDINGS	**$0.60**
50 IRE 23.S1 Standards on Television: Methods of Measurement of Television Signal Levels. Resolution, and Timing of Video Switching Systems, 1950. Reprinted from the May, 1950, PROCEEDINGS	**$0.70**
54 IRE 23.S1 Standards on Television: Methods of Measurement of Aspect Ratio and Geometric Distortion, 1954. Adopted by ASA. (ASA C16.23-1954.) Reprinted from the July, 1954, PROCEEDINGS	**$0.60**
55 IRE 23.S1 Standards on Television: Definitions of Television Signal Measurement Terms, 1955. Reprinted from the May, 1955, PROCEEDINGS	**$1.00**
58 IRE 23.S1 Standards on Television: Measurement of Luminance Signal Levels, 1958. (ASA C16.31-1959.) Reprinted from the February, 1958, PROCEEDINGS	**$0.60**
50 IRE 23.S2 Standards on Television: Methods of Measurement of Time of Rise, Pulse Width, and Pulse Timing of Video Pulses in Television, 1950. Reprinted from the November, 1950, PROCEEDINGS	**$0.75**
50 IRE 23.S3 Standards on Television: Methods of Measurement of Electronically Regulated Power Supplies, 1950. Reprinted from the January, 1951. PROCEEDINGS	**$0.75**
45 IRE 24.S1 Standards on Radio Wave Propagation: Definitions of Terms Relating to Guided Waves, 1945	**$0.20**
50 IRE 24.S1 Standards on Wave Propagation: Definitions of Terms, 1950. Reprinted from the November, 1950, PROCEEDINGS	**$0.60**
55 IRE 26.S1 Standards on Graphical and Letter Symbols for Feedback Control Systems, 1955. Reprinted from the November, 1955, PROCEEDINGS	**$0.25**
55 IRE 26.S2 Standards on Terminology for Feedback Control Systems, 1955. Reprinted from the January, 1956, PROCEEDINGS	**$0.50**
56 IRE 27.S1 Standards on Methods of Measurement of the Conducted Interference Output of Broadcast and Television Receivers in the Range of 300 KC to 25 MC, 1956. Adopted by ASA. (ASA C16.25a-1957.) Reprinted from the August, 1956, PROCEEDINGS	**$0.50**
58 IRE 27.S1 Supplement to "IRE Standards on Receivers: Methods of Measurement of Interference Output of Television Receivers in the Range of 300 to 10,000 KC 1954" (Standard 54 IRE 17.S1). (ASA C16.25b-1959.) Reprinted from the July, 1958, PROCEEDINGS	**$0.50**
56 IRE 28.S1 Standards on Letter Symbols for Semiconductor Devices, 1956. Reprinted from the July, 1956, PROCEEDINGS	**$0.50**
58 IRE 28.S1 Standards on Solid-State Devices: Methods of Testing Point-Contact Transistors for Large, Signal Applications, 1958. Reprinted from the May, 1958. PROCEEDINGS	**$0.70**
56 IRE 28.S2 Standards on Solid-State Devices: Methods of Testing Transistors, 1956. Reprinted from the November, 1956, PROCEEDINGS	**$0.80**

CEDAR RAPIDS PGAP HOLDS SYMPOSIUM

The Symposium on Antennas and Propagation held by the Cedar Rapids, Iowa, Section, September 18 and 19, 1959, brought to more than 165 members of the section authorities in their fields who delivered papers reviewing the current state of the art. The papers by Dr. A. D. Wheelon and Dr. J. D. Dyson were of particular interest since they presented material never before published. Dr. Wheelon, who reviewed scatter propagation theory, had just completed a two-week session at the National Bureau of Standards, Boulder, Colo., with proponents of the various scattering theories. His paper reflected the results of this meeting. Dr. Dyson described another class of frequency independent antennas having characteristics similar to the logarithmic-periodic antennas and derived from equiangular spiral shapes.

MICROWAVE TUBES CONGRESS ISSUES CALL FOR PAPERS

The International Congress on Microwave Tubes, to be held in Munich, Germany, June 7–11, 1960, has announced that the deadline for papers is December 30, 1959. The subjects for discussion at the convention will be treated in the following groups: Diode and Grid Controlled Fields, Velocity-Modulation Tubes, Traveling-Wave Tubes, O- and M-Type Backward-Wave Oscillators, Magnetrons and M-Type Amplifier Tubes, Cavities and Slow-Wave Structures, Space-Charge Waves, Noise, Electron Guns and Beam Focusing, Parametric Amplifiers—Masers, Gas-Discharge Tubes, Generation of Electromagnetic Energy by Radiation (Undulator, Cerenkov Effect, etc.), Measuring Techniques, and Technology.

Papers may be read in German, English or French. The maximum time allocated to each paper is 20 minutes. Three copies of a short summary (less than 50 lines) should be enclosed with the form and sent to:

Vortragsausschuss der Internationalen Tagung, "Mikrowellenrohren," z. Hd. Herrn Prof. Dr. W. Kleen, Munchen 8, Balanstrasse 73, Germany.

The program committee will inform the authors by about February 15, 1960, whether their papers have been accepted. The summaries of accepted papers will be printed and made available on or before the date of the Congress.

AIR FORCE ANNOUNCES MARS DECEMBER SCHEDULE

The December schedule of the Air Force MARS Eastern Technical Net, to be heard Sundays from 2 to 4 P.M., EST at 3295 kc, 7540 kc, and 15,715 kc, is as follows:

December 6	"UHF Air-Sea Rescue Communications," T. C. Nehrbas, Ch. Eng., and J. E. Richter, Proj. Eng., Telephonics, Inc.
December 13	"Underwater Sound Detection," G. D. Cummings and W. Love, Proj. Engs., Telephonics, Inc.
December 20	"Reinforced Plastics," W. H. Greenberg, Ch. Eng., Riverside Plastics Corp.
December 27	Recess date.
January 3	Recess date.

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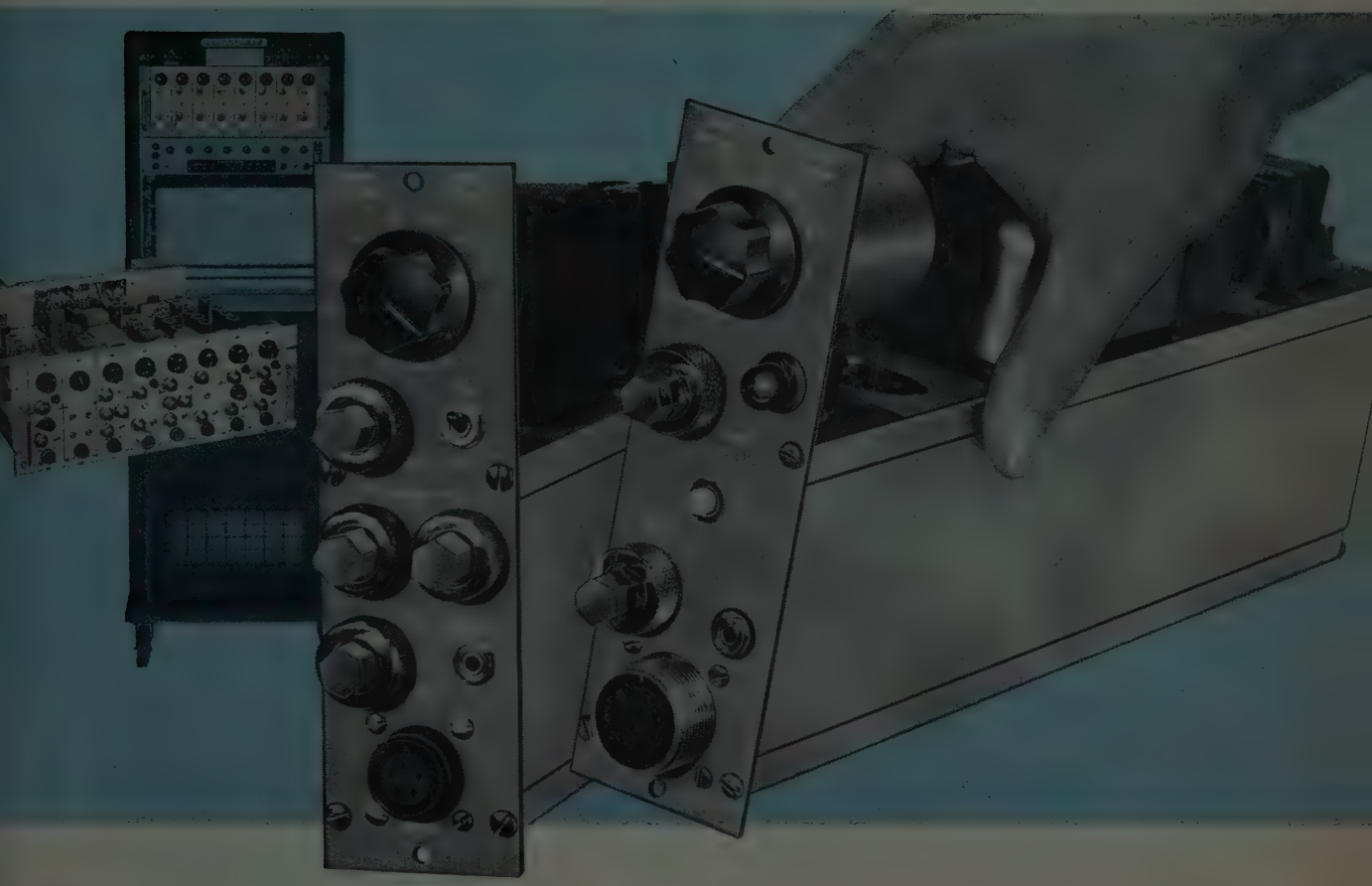

With the availability of these two new plug-in preamplifiers and associated MOPA, Sanborn 6- and 8-channel "850" oscillographic recording systems can now record an even *wider* variety of inputs — wherever *many channels* are needed in *minimum panel space*, with *no* sacrifice in system accuracy or reliability. The 850-1100A is a carrier amplifier-demodulator unit designed to work with resistance bridge, variable reluctance and differential transformer transducers. Attenuator, smooth gain, position and balancing controls are on the 2″ x 7″ front panel; input and output connections are provided at both front and rear. The 850-1500A is a chopper amplifier with floating input isolated from a floating output, capable of measuring low level DC-100 cps signals such as those from thermocouples and strain gage bridges. Design provides low noise operation, greater freedom from ground loop interference and high common mode rejection ratio. Required carrier excitation (2400 cps standard, 600, 1200 and 4800 cps optional) and chopper drive (440 cps) voltages are supplied by the 850-1900 MOPA, a dual-oscillator unit which can handle up to eight of each preamplifier.

SPECIFICATIONS

	850–1100A	850–1500A
Sensitivity	100 μv in gives 1 v at output	
Input impedance	approx. 2500 ohms	approx. 100,000 ohms
Output	±2.5v across 3300 ohms	±2.5 volts across 2500 ohms
Freq. response	−3 db at 20% of carrier freq.	0–100 cps, −3db
Linearity	±0.5% of full scale	±0.1% of full scale
Common mode performance		120 db for 60 cps, 160 db for DC with 5000 ohms unbalance in input
Noise		2 μv p-p over 100 cps bandwidth

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Eta Kappa Nu Presents Awards to Young Engineers

Dr. Edgar A. Sack, Jr. (S'49–A'55–M'56) of Pittsburgh, Pa. has been named the Outstanding Young Electrical Engineer of 1959 in the annual nationwide talent search conducted by Eta Kappa Nu, national electrical engineering honor society. Willard B. Groth, Chairman of the Award Organization Committee of the society, also announced today that Honorable Mention awards in the national competition had been made to William O. Fleckenstein (A'52–M'57) of Whippany, N. J., Kenneth H. Olsen (S'48–A'53), of Bedford, Mass., and John W. Wentworth (S'48–A'50–M'55) of Haddonfield, N. J.

The 1959 competition is the twenty-fourth in the series which began in 1936. Formal presentation of the awards will be made at a banquet to be held during the Winter General Meeting of the AIEE in New York, N. Y., in February.

At 29 years of age, the 1959 Outstanding Young Electrical Engineer has a record of accomplishment in the field of solid state device research and development. Initially, Dr. Sack contributed to the understanding of dielectric amplifiers through his doctoral research in connection with ferroelectric materials and their use in resonant dielectric amplifiers. Most recently, he has been responsible for advances in electroluminescence and the application of this principle to practical solid state display mechanisms. His efforts have made possible an electroluminescent alpha-numeric and digital indicator as well as high resolution microcircuit structures for flat panel mural television displays valuable for Navy command information centers. He supervised the design and installation of the first full installation of electroluminescent panels for room lighting in 1956.

He received his education at the Carnegie Institute of Technology, being awarded the B.S., M.S., and Ph.D. degrees in 1951, 1952, and 1954, respectively. He joined the Research Laboratories of Westinghouse Electric Corporation in 1954 as a member of the television section of the Electronics and Nuclear Physics Department. At present he is Manager, Dielectric Devices Section, responsible for the direction of research on special dielectric devices such as electroluminescent displays.

William O. Fleckenstein, one of the Honorable Mention citation recipients, is 34 years of age. A native of Scranton, Pa., he was graduated from Lehigh University as the highest ranking senior in electrical engineering in 1949. He joined the Bell Telephone Laboratories, Inc., immediately upon graduation and participated in their communication Development Training Program. Upon completion of the program he began a telephone career which has been marked by creative accomplishment.

His principal contributions have been made in the areas of electronic switching systems, high speed magnetic core memory systems, and data transmission and record communication systems. He has taught extensively in the Laboratories' Communication Development Training Program.

Kenneth H. Olsen, another Honorable Mention recipient, at 33, is a specialist in the development of solid state components and circuitry for digital computation equipment in addition to being the founder and president of a corporation that has annual sales in excess of a million dollars within two years of its organization.

Mr. Olsen, a native of Bridgeport, Conn., received the B.S. and M.S. degrees in electrical engineering from the Massachusetts Institute of Technology in 1950 and 1952. As a graduate student, he invented a magnetic matrix switch for use with coincident current magnetic memories. Following graduation, as a staff member of the Digital Computer Laboratory of M.I.T. he supervised the group responsible for the first digital computer to use the magnetic core random-access memory. Later he was one of the first to build a high performance digital computer using transistors. In 1957 he founded and became president of Digital Equipment Corporation, a concern that has enjoyed remarkable financial success in the creation and marketing of transistorized building blocks for the computer industry.

The field of electronics also contributed the third winner of an Honorable Mention citation in the 1950 competition. John W. Wentworth, 33, is Manager of Television Terminal Engineering in RCA's Industrial Electronic Products Division. A native of Greenville, Maine, he was graduated from the University of Maine with a bachelor's degree in electrical engineering in 1949. He joined RCA shortly after graduation, and has been a major contributor to that organization's important advances in color television.

He has taught and lectured extensively on the subject of color television. His book, *Color Television Engineering*, was published in 1955.

The Eta Kappa Nu award is given to an electrical engineer who on May 1 of each year has not been graduated more than ten years from a regular course in electrical engineering from an American college or university, and who is not more than 35 years of age. Selection is made on the basis of the candidate's record of achievement in his chosen work, in his service in behalf of his community, state or nation; in his cultural or aesthetic development; and for his professional activities.

Professional Group News

The following Chapters were approved by the IRE Executive Committee at its meeting held on October 7th: PG on **Automatic Control**—New York Chapter; PG on **Electron Devices**—Syracuse Chapter; PG on **Reliability and Quality Control**—Joint Metropolitan New York, North New Jersey and Long Island Chapter.

OBITUARIES

Roscoe Kent, a Senior Member of the IRE, died recently at the age of 74. A pioneer in the field of radio, he was one of the early members of the IRE.

Mr. Kent was born in St. Paul, Minn., on February 22, 1885. After attending school in St. Paul, he enlisted in the U. S. Navy in 1902. From 1902 to 1906, while in the Navy, he studied the radio field, through correspondence courses, special courses, and handbooks. In 1906 he became Chief Engineer of the Radio Telephone and Telegraph Co., where he worked with the design, fabrication, and installation of wireless telephone and telegraph equipment, and motor generators and wood and steel towers and buildings. He sold and installed the first radio telephones to the U. S. Navy. In 1910 he joined the Mathews Gravity Conveyor Co., Ellwood City, Pa., and in 1912 he became a consulting engineer, developing and building small railroads and ships. During World War I he acted in undercover service for the U. S., and also was Superintendent of the George B. Curd Car and Locomotive Shops, Cincinnati, Ohio. For the next ten years he was Vice President of Florida Associated Engineers, Orlando, Fla., where he helped to design, sell, and install road machinery and equipment. In 1929 he developed a police radio which was produced by the DeForest Radio Co., Passaic, N. J., and for the next few years he did consulting work again. In 1935 he became Assistant General Manager of Wired Radio, Newark, N. J., developing such equipment as high fidelity phonograph records and pick ups, water cooled radio tubes, and carrier current systems. He also had charge of introducing these items to trade and selling patent licenses. Later, he designed, equipped, and put into operation the plant of Tools, Inc., Newark, N. J. During World War II he was in charge of War Contracts Div., Gemex Co., Union, N. J., and after the war he became consultant and patent adviser at Radio Inventions, Inc., New York, N. Y. For the past several years he had been the Florida Representative for Industrial Instruments, Inc., Cedar Grove, N. J.

Mr. Kent was a member of the Society of American Military Engineers and the American Society of Mechanical Engineers. He was a founder of Radio Pioneers.

Thomas E. Goldup (SM'52–F'55), Director of Mullard Ltd., London, England, died recently at the age of 65. He was head of the research and development work at Mullard, and directed its technical policy.

T. E. Goldup

He was born on April 30, 1894, in London, Eng., and attended the Royal Naval College, Greenwich, from 1910 to 1914, where he majored in Applied Electrical Engineering and Applied Physics. From 1913 to 1914 he was on the staff of the college.

In 1914 he was appointed to the research staff of Signal School, Portsmouth, and in 1918 he became Senior Experimental Officer at the school. While there he designed and developed the early 2.5 kw silica tubes for the British Navy. In 1923 he joined Mullard Radio Valve Co. as assistant in the Valve Laboratory. Five years later he was appointed Head of the Technical Service Department, and in 1938 he became Director of Mullard Equipment Ltd. In 1940 he became Director of Mullard Radio Valve Co. Ltd., and in 1951 he was appointed Director of Mullard Ltd., encompassing both the Radio Valve and Equipment Companies.

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This transmitter is recommended for use with ARC's line of tunable receivers, (R-13B and R-19) for a primary communication system on small aircraft or as a "back-up" to ARC Type 210 Transmitter-Receiver on larger aircraft.

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Sixth National Symposium on Reliability and Quality Control in Electronics

STATLER-HILTON HOTEL, WASHINGTON, D. C., JANUARY 11–13, 1960

The Sixth National Symposium on Reliability and Quality Control in Electronics, sponsored by the PGRQC, AIEE, ASQC and EIA, will be held January 11–13, 1960, at the Statler-Hilton Hotel, Washington, D. C.

Registration fees for members of the IRE, AIEE or ASQC are $20.00 in advance, and $24.00 at the door. The fee for nonmembers is $22.00 or $24.00.

Monday Morning, January 11

Session 1—Keynote address

"Reliability—Responsibility," *J. K. Sprague, Sprague Electric Co.*

Session 2A—Military Requirements and Specifications

Chairman: *J. Allen, Space Technology Labs., Inc.*

"Reliability in Contracts," *J. L. Burnside, Lockheed Aircraft Corp.*

"Improved Component Specifications," *R. E. Moe, General Electric Co.*

"New Quality Assurance Techniques in Specifications," *H. G. Romig, Hoffman Electronics Corp.*

Session 2B—New Production Techniques

Chairman: *A. W. Rogers, U. S. Army Signal Res. and Dev. Lab.*

"New Production Techniques on Filters and Capacitors," *S. Sonobe, Nippon Elec. Co.*

"Audio-Visual Aids to Human Reliability," *D. A. Hill, Hughes Aircraft Co.*

"Decentralized Reliability Education," *J. M. Wuerth, North American Aviation, Inc.*

Monday Afternoon

Session 3A—New Mathematical Techniques

Chairman: *G. Levenbach, Bell Tel. Labs.*

"Random Balance Designs for Reliability," *G. H. Sandler, Sylvania Elec. Prods., Inc.*

"Sequential Qualification: A Reliability Countdown," *D. R. Howes, Army Chemical Center.*

"Analog Computers for Statistical Procedures," *M. H. Norton, Booz-Allen Applied Res., Inc.*

"Accelerated Testing as a Problem of Modeling," *R. E. Thomas, Battelle Mem. Inst.*

Session 3B—Cost Considerations

Chairman: *Rear Admiral R. Mandelkorn (USN, Ret.) Philco Div., Lansdale Tube Co.*

"A Reliability Economic Decision Method," *H. W. Price, Diamond Ordnance Fuze Lab.*

"The Cost of Reliability Versus Maintenance Cost," *Lt. Col. W. F. Stevens, Wright Air. Dev. Center.*

"Rework Costs Related to Reliability Requirements," *W. R. Kuzmin, Packard Bell Electronics.*

"An Information Theory Approach to Diagnosis," *R. A. Johnson, Syracuse, Univ.*

Monday Evening

Session 4—Round Table Discussion

Chairman: *J. M. Bridges, Office of Electronics, ODDR&E.*

Participating: *Advisory Board Members.*

Tuesday Morning, January 12

Session 5A—Training Session

Chairman: *R. Fitzgibbons, Raytheon Co.*

"Mathematics of Reliability," *J. M. Weisen, Sandia Corp.*

"Circuit Design Concept for High Reliability," *F. E. Dreste, Motorola, Inc.*

"Prediction of Reliability," *J. Conners, Hughes Aircraft Co.*

"Design Review," *G. J. Armbruster, RCA.*

Session 5B—Failure Modes

Chairman: *G. Neuschaefer, New York Naval Material Lab.*

"Resistor Reliability—Capability Analysis," *B. R. Schwartz, RCA.*

"Failure Modes in Electronic Components," *M. L. Granberg, Sperry Rand Corp.*

"Modes of Failure of Component Parts," *C. D. Jeffcoat, Westinghouse Electric Corp.*

"Part Improvement in Missile Guidance Applications," *J. Hepp, General Motors Corp.*

Session 5C—Advanced Mathematical Theory

Chairman: *G. M. Cox, Research Triangle Inst.*

"Negative Moments and the Evaluation of Reliability," *W. Mendenhall, Bucknell Univ.*

"Multi-factor Experiments in Life Testing," *M. Zelen, Nat. Bur. of Stand.*

"A Summary of Some New Techniques on Failure Analysis," *J. K. Kao, Cornell Univ.*

"Estimation of Reliability from Incomplete Data," *G. R. Herd, Booz-Allen Applied Res., Inc.*

Tuesday Afternoon

Session 6A—Training Session

Chairman: *R. Fitzgibbons, Raytheon Co.*

"Reliability Testing," *J. H. Hershey, Bell Tel. Labs.*

"Failure Reporting," *E. Gould, Hughes Aircraft Co.*

"Manufacturing Aspects of Reliability," *T. Wos, Westinghouse Electric Corp.*

"Field Reliability," *J. C. Burns, ARINC Corp.*

Session 6B—Reliability Prediction

Chairman: *J. A. Connors, Hughes Aircraft Co.*

"Correlation of Laboratory and Field Reliability, *C. M. Bird, IBM Corp.*

"Reliability Prediction—A Proven Method," *W. T. Tier, General Electric Co.*

"The Practicality of Predicting Reliability Numbers," *W. E. Boyes, Sandia Corp.*

"Prediction of MTBF Bounds in Early Design," *B. Tiger, United Aircraft Corp.*

Session 6C—Information Exchange Panel

Chairman: *R. H. DeWitt, Office of Electronics, ODDR&E.*

"The Tri-Service and NOL Program," *M. Barbe, Space Technology Labs., Inc.*

"Battelle Memorial Institute Data Pool," *C. R. Deeter, Battelle Mem. Inst.*

"ODD Ad Hoc Committee on Component Reliability," *J. Glass, Hughes Aircraft Co.*

"Inland Testing HELPER Program," *L. L. Schneider, Inland Testing Labs.*

"Information Exchange Mechanics," *R. M. Jacobs, Sylvania Electronic Systems Div.*

"Product Standardization and Technical Data Exchange," *E. F. Howrey, Attorney and partner with Law Firm of Howrey and Simon.*

Tuesday Evening

Session 7—Banquet

"Research and Development Aspects of Reliability," *Vice Admiral J. T. Hayward, USN, Assistant Chief of Naval Operations.*

Wednesday Morning, January 13

Session 8A—New Maintainability Techniques

Chairman: *Gen. F. L. Ankenbrandt (USA, Ret.), RCA.*

"Maintenance Planning During Equipment Development, *R. I. Moeller, IBM.*

"Maintainability Study on Shipboard Electronics," *J. Schechtel, Fed. Elec. Corp.*

"Practical Maintainability Numerics," *M. P. Feyerherm, RCA.*

"RADC Maintainability Program," *M. P. Forte, Rome Air. Dev. Center.*

Session 8B—Life Tests

Chairman: *W. Sumerlin, Philco Corp.*

"Life Test Acceptance Plans," *B. Epstein, Stanford Univ.*

"High Temperature Burn-In for Silicon Diodes," *D. Cowan, Continental Device Corp.*

"The Selection of Components for Test Purposes," *W. G. Madow, Stanford Res. Inst.*

"Surface Barrier Transistor Life Characteristics," *J. Drennan, Battelle Mem. Inst.*

Wednesday Afternoon

Session 9A—System Aspects

Chairman: *P. S. Darnell, Bell Tel. Labs.*

"Design Reliability Analysis—A Proven Technique," *H. Wuerffel, RCA.*

"Some Effects of Redundancy on System Reliability," *H. S. Balaban, ARINC Corp.*

"Reliability, The Engineer, and the Mathematician," *G. W. Holtzman and W. E. Marshall, Minneapolis-Honeywell Reg. Co.*

"Reliability Measurement Applicable to Vigilante," *W. M. Roberts, U. S. Army Ordnance & Proof Services.*

Session 9B—Programs and Management

Chairman: *Col. R. O. Mitterling, Hdqtrs., Air Material Command.*

"A Field Reliability Data Program," *J. R. Holmes, IBM.*

"Designing in the Dark," *J. M. Farrier, ARINC Corp.*

"Small Samples are Significant," *S. J. Wilson, The Martin Co.*

"Supplier Reliability Assurance Program," *M. H. Saltz, Hughes Aircraft Co.*

INFINITE HORIZONS

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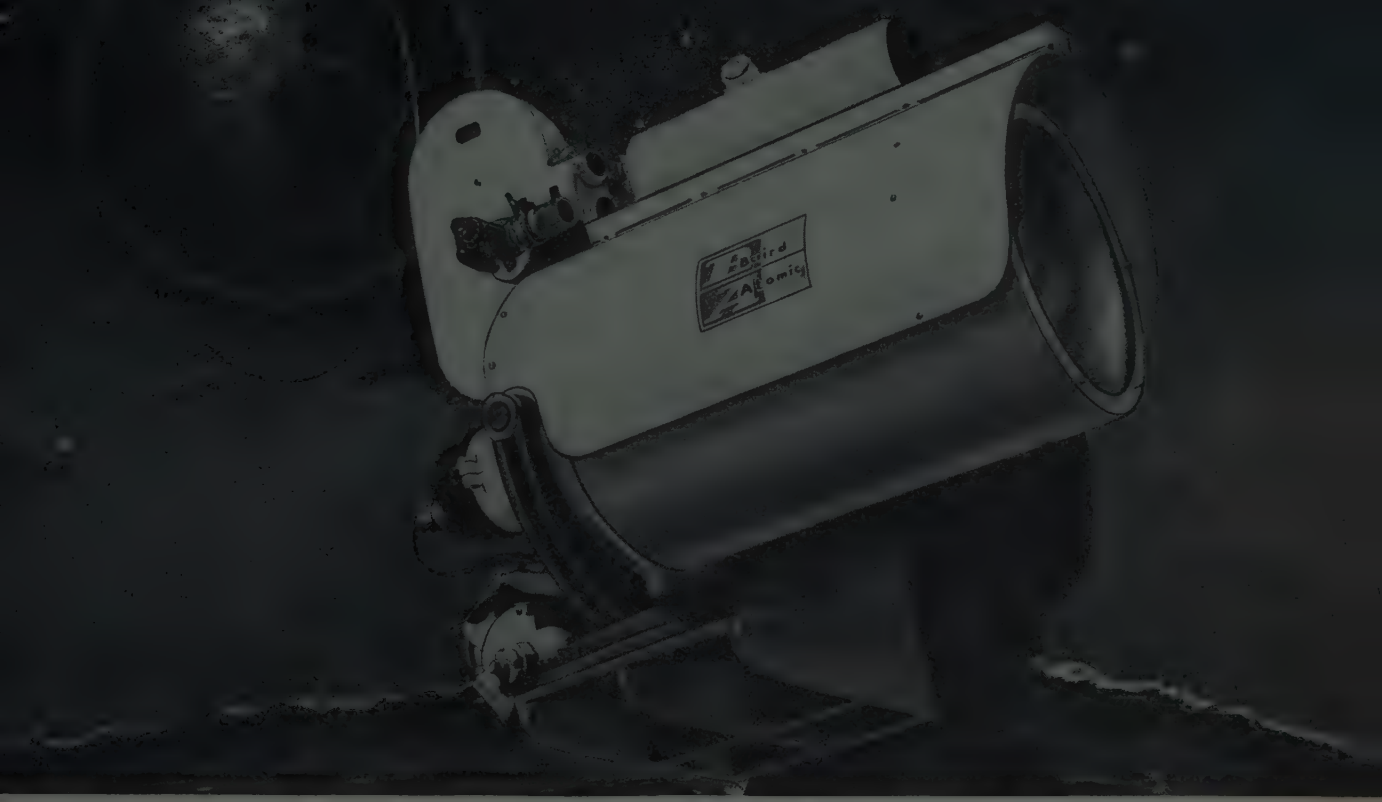

Airborne Search

The B/A transistorized "ROYAL FLUSH" Airborne Scanning, Detecting and Spectral Systems evaluate infrared radiation from airborne targets — also used to study radiation transmission at extremely high altitudes . . .

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Baird-Atomic has also been a pioneer in commercial infrared instrumentation — first to market a double-beam recording spectrophotometer. B/A's development program continues to pace the field in infrared analysis.

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B/A tracking telescopes, as shown above, are in regular use at several locations. These unique systems can use visible, near or far infrared signals.

With a background of many years of advanced scientific and engineering effort in infrared, Baird-Atomic has developed and delivered a number of ground-based and airborne systems for special government requirements. B/A's backlog in this field has risen sharply, with major new commitments for the Missiles and Space Division of Lockheed Aircraft Corporation. Baird-Atomic's responsibilities include the development and delivery of specialized systems for important new applications in space programs. Other programs for infrared system development for the government show continued growth.

The expansion of infrared projects at B/A and the continued growth of national and world markets have created new openings for scientists, designers and production engineers. Unusual opportunities are yours, if you qualify. For details, write to: Personnel, Baird-Atomic, Department Y.

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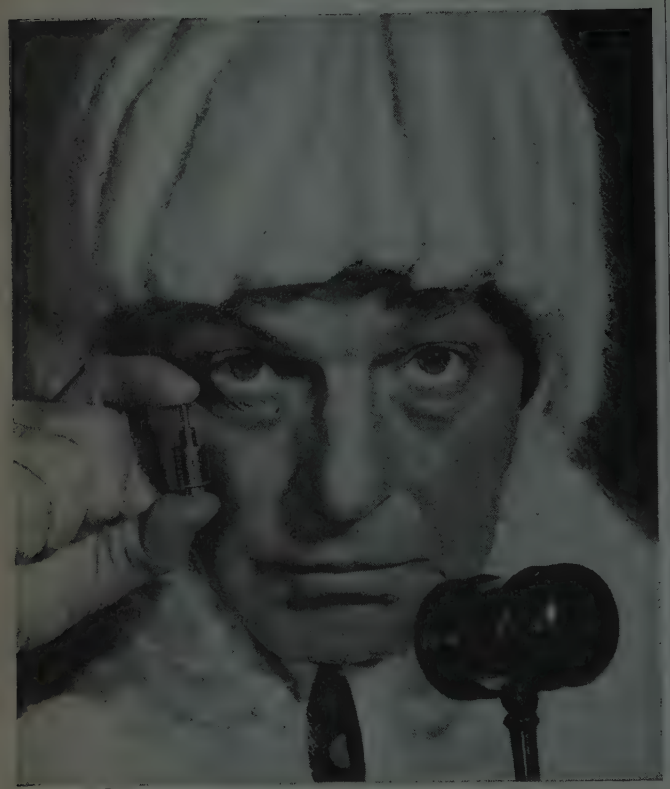
Waters has a watertight case!



APW½ ½" dia.

Waters APW½ Sealed Potentiometer is so watertight and so heat resistant that it operates reliably even in boiling water! The APW½ is completely unaffected by humidity and water vapor, the two common causes of potentiometer failures in aircraft and missiles, where pressure and altitude changes allow equipment "to breathe". Naturally, the watertight construction of the APW½ also seals out dust and other minute particles which might cause failure. Meets MIL-E-5272A immersion specifications by means of a double "O" ring shaft seal. The glass-to-metal terminal board is solder-sealed to the case. Available with 125°C or 150°C construction, mechanical rotation stops, special winding angles, values to 100K and tighter linearity tolerances. Can be supplied with optional split bushings and various shaft lengths. (Waters WPW½ Sealed Potentiometer features the same construction as the APW½, but with a servo face.) Write for Bulletin APW-359.

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INSTRUMENTS

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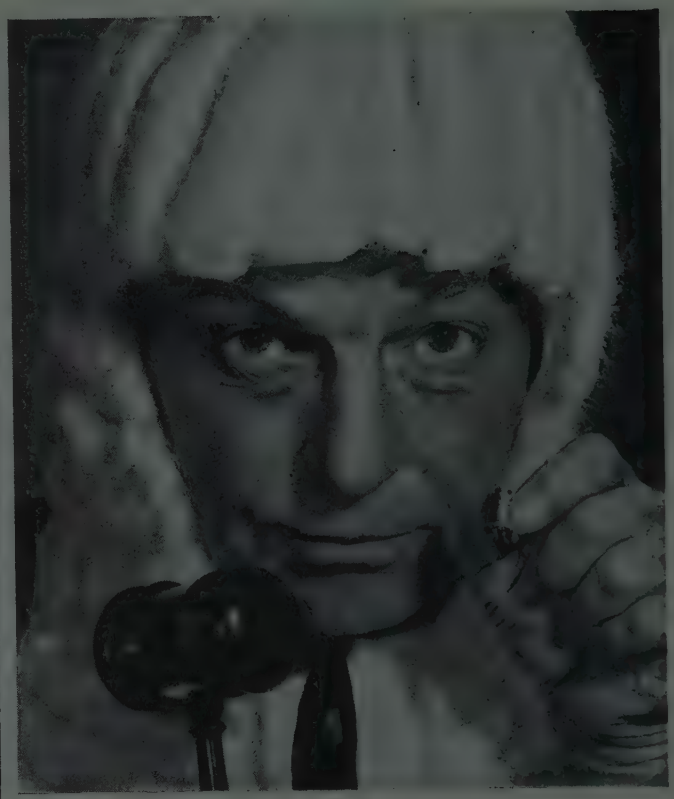

APH½ ½" dia.

Waters APH½ hermetically sealed precision potentiometer, in addition to maintaining the hermetic seal behind the panel, is itself tightly sealed against outside atmosphere and salt spray by means of a double "O" ring shaft seal. The entire potentiometer passes Liquid Immersion Tests per MIL-E-5272A, par. 4.12.1, and, excluding the shaft, passes the Mass Spectrometer Test with leak rate less than 10^{-7} CC/sec. N.T.P. Pre-tinned, it can be easily soldered into the panel. Its terminal lugs are installed with a glass to metal seal, and are positioned for easy wiring. The brass case is plated in conformance with military requirements. Waters APH½ HT Potentiometer also has high temperature operating characteristics. It derates to zero watts at 150°C; ¾ watts may be safely dissipated at 125°C. Available with mechanical rotation stops, special winding angles, resistance values to 100K ohms and tighter linearity tolerances. Write for Bulletin APH.

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INSTRUMENTS

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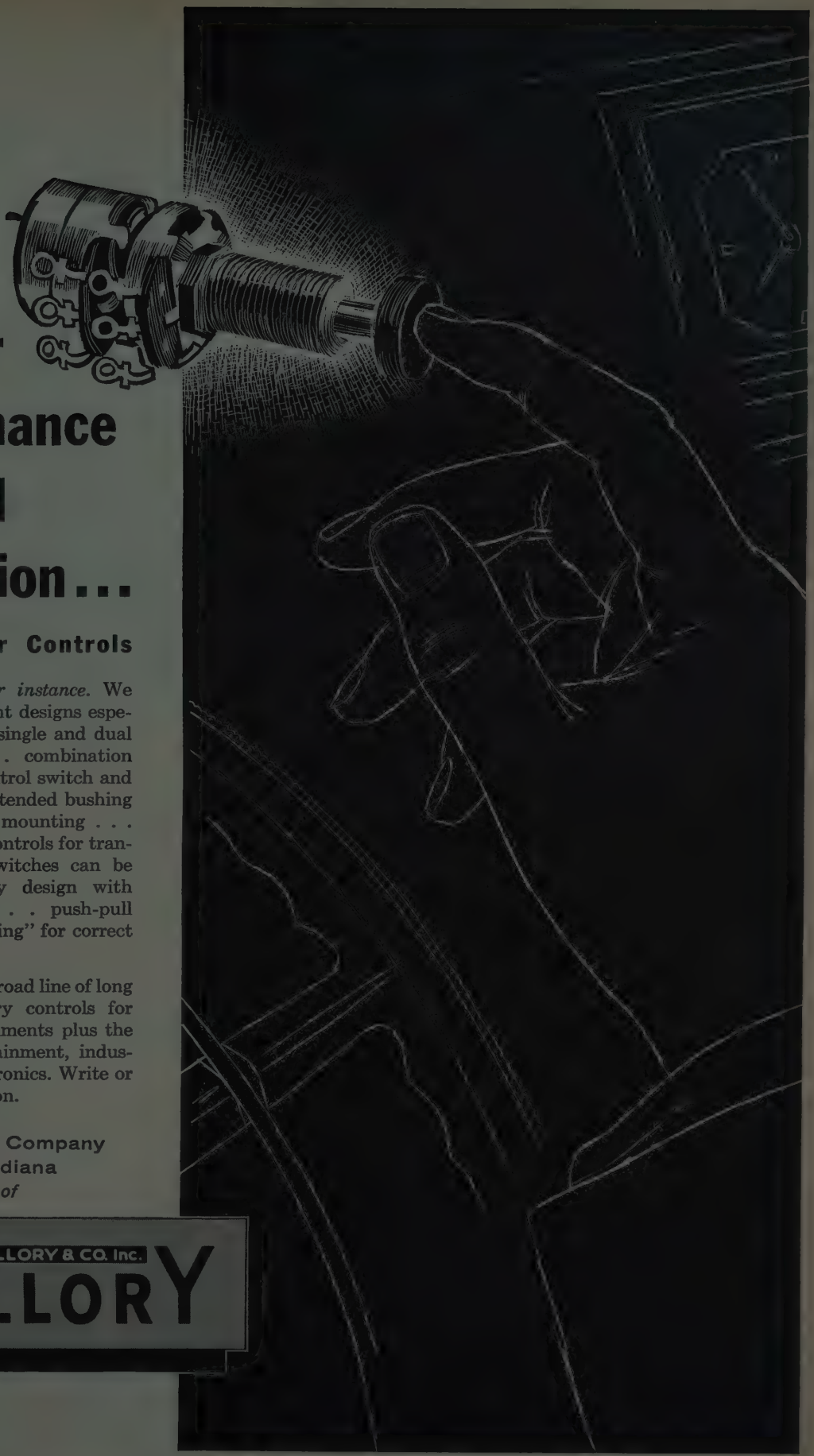

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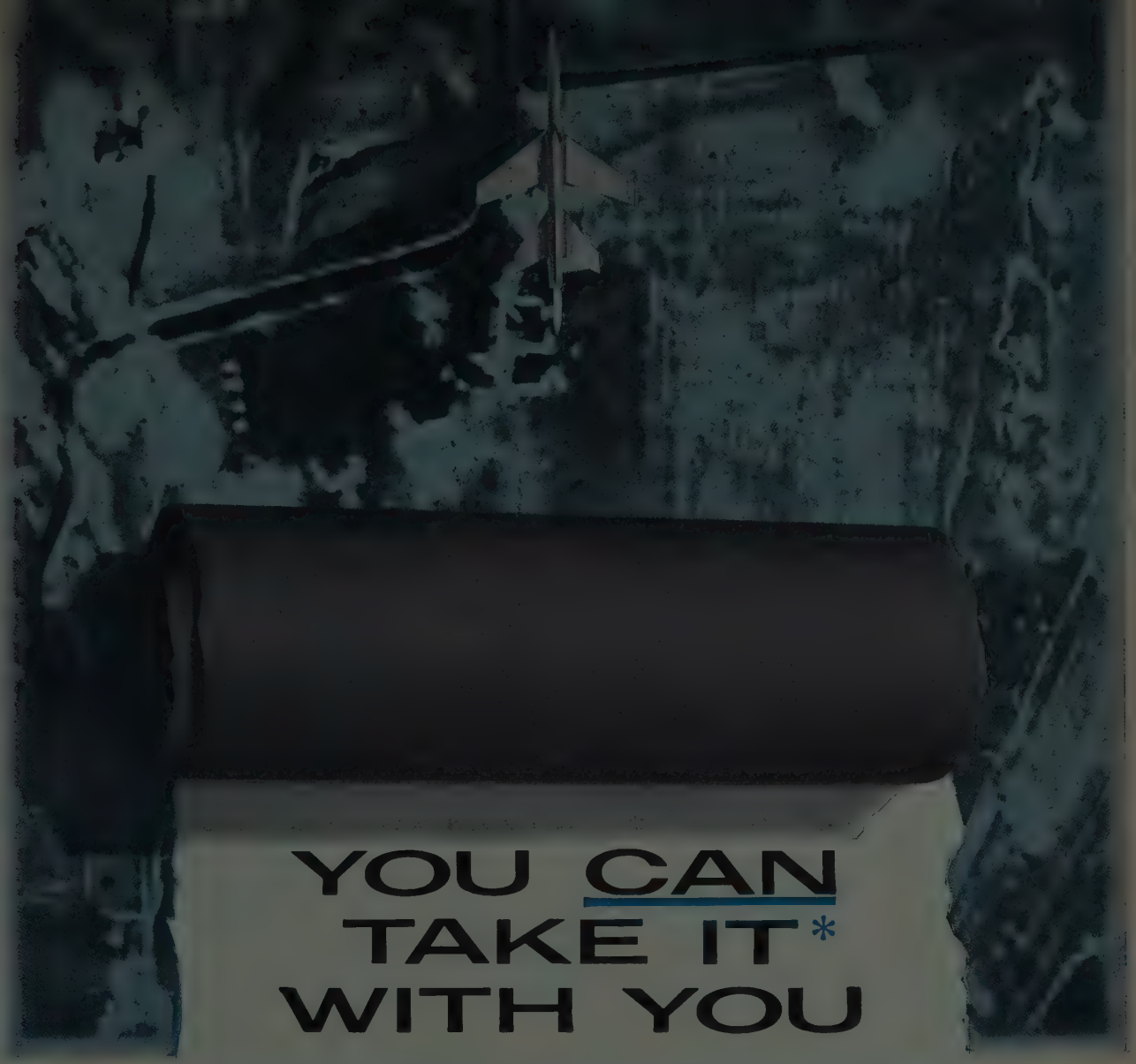

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APPARATUS DIVISION

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NOW!
4 new microwave sweep oscillators

speed, simplify measurements 2.0 to 18.0 KMC

Covers full band, or any part
Use with 'scope or recorder
All electronic; no mechanical sweep
Direct reading, independently adjustable sweep range and rate controls

◀ Figure 1. Arrangement for high speed microwave measurement to provide rapid visual display with hp 130A/B oscilloscope.

hp Dependable, quality

Hewlett-Packard Electronic Sweep Oscillators are new measuring tools deliberately designed to give you simpler, faster microwave measurements. Four models are provided, covering frequencies 2.0 to 18.0 KMC as follows: Model 683A, 2.0 to 4.0 KMC; Model 684B, 4.0 to 8.1 KMC; Model 686A, 8.2 to 12.4 KMC and Model 687A, 12.4 to 18.0 KMC.

These instruments make possible microwave investigations and evaluations with a convenience previously associated only with lower frequency measurements. These oscillators provide a wide range of sweep speeds so that measurements of reflection, attenuation, gain etc., can be displayed on an oscilloscope or recorded in permanent form on X-Y or strip-chart recorders.

Electronic Sweeping

Specifically, the new oscillators provide either a CW or swept rf output throughout their individual bands. The instruments employ new backward wave oscillator tubes whose frequency is shifted by varying an applied potential. Thus, troublesome mechanical stops and tuning plungers are eliminated. Sweep range is continuously adjustable and independently variable; sweep rate is selected separately, and either can be changed without interrupting operation. The full band width can be covered in time segments ranging from 140 seconds (very slow for mechanical recorder operation) to 0.014 seconds (high speed for clear, non-flickering oscilloscope presentation).

Linear Frequency Change

The swept rf output from the hp sweep oscillator is linear with time, and a linear sawtooth voltage is provided concurrent with each rf sweep to supply a linear time base for an oscilloscope or recorder. In addition, for convenience in recording and other operations, rf sweeps can be triggered electrically externally and single sweeps can be triggered by a front panel push button. The rf output can also be internally AM'd from 400 to 1,200 cps and externally AM'd or FM'd over a wide range of frequencies.

Rapid Visual Presentation

The variety of sweep rates and band widths available from the new oscillators insures convenience and accuracy for reflection and transmission coefficient measurements and many other production line and laboratory tests. For maximum speed, an oscilloscope such as hp 130A/B may be used as indicated in the diagram on opposite page. For maximum information and a permanent record, an X-Y or strip chart recorder may be used.

Complete details of a rapid visual method using an oscilloscope or a maximum-data, permanent record method using a recorder may be obtained from your hp field engineer. Detailed discussions of these methods are also contained in the hp Journal, Vol. 8, No. 6, and Vol. 9, No. 1-2, available on request.

TYPICAL SPECIFICATIONS

Below are specifications for *-hp-* 686A Sweep Oscillator, 8.2 to 12.4 KMC. Specifications for *-hp-* 683A, 684B, and 687A (P band) are similar except for frequency range and other minor variations.

Types of Outputs: Swept Frequency, CW, FM, AM.

Single Frequency Operation

Frequency: Continuously adjustable 8.2 to 12.4 KMC.

Power Output: At least 10 milliwatts into matched waveguide load. Continuously adjustable to zero.

Swept Frequency Operation

Sweep: Recurrent; externally triggered; also manually triggered single sweep. Rf sweep linear with time.

Power Output: At least 10 MW into matched waveguide load. Output variation less than 3 db over any 250 MC range; less than 6 db over entire 8.2-12.4 KMC range.

Sweep Range: Adjustable in 7 steps 4.4 MC to 4.4 KMC.

Sweep Rate-of-Change: Decade steps from 32 MC/sec. to 320 KMC/sec.

Sweep Time: Determined by sweep range and rate; from 0.014 to 140 seconds over full-band.

Sweep Output: +20 to +30-volt-peak sawtooth provided at a front-panel connector concurrent with each rf sweep.

Modulation

Internal Amplitude: Square wave modulation continuously adjustable from 400 to 1200 cps; peak rf output power equals cw level ± 1 db.

External Amplitude: Direct coupled to 300 KC; 20 volt swing reduces rf output level from rated cw output to zero.

External Pulse: +10 volts or more, 5 millisecond maximum duration.

External FM: Approx. 350 v peak to modulate full frequency range.

General

Input Connectors, Impedances: BNC; above 100,000 ohms.

Output Connector: Waveguide cover flange (686A, 687A); Type N, female (683A, 684B).

Power Requirements: 115/230 volts ±10%, 50/60 cps; approximately 540 watts.

Price: hp 683A (2.0 to 4.0 KMC) $3,000.00.
hp 684B (4.0 to 8.1 KMC) $2,900.00.
hp 686A (8.20 to 12.40 KMC) $2,900.00.
hp 687A (12.40 to 18.00 KMC) $3,400.00.

(Prices above are f.o.b. factory for cabinet models. Rack mount instruments $15.00 less.)

Data subject to change without notice.

HEWLETT-PACKARD COMPANY

4478D Page Mill Rd. • Palo Alto, California, U.S.A.
Field Representatives in All Principal Areas
Cable "HEWPACK" DAvenport 5-4451

instruments that speed and simplify your work

EIMAC
is an electron tube specialist

EIMAC FINDS WAY TO END PREMATURE TUBE FAILURE

No matter how carefully you operate vacuum tubes, power overloads can't always be avoided. In most tubes, the resultant overheating produces vacuum loss or internal arcing. Tubes often fail immediately or fall off in performance.

To overcome this, Eimac developed a group of internal-anode radial-beam tetrodes with exceptional ability to withstand repeated power overloads and peak powers. Operated for millions of hours in every class of service, these rugged tetrodes have proved they last longer, *perform better*, than any comparable internal-anode tubes.

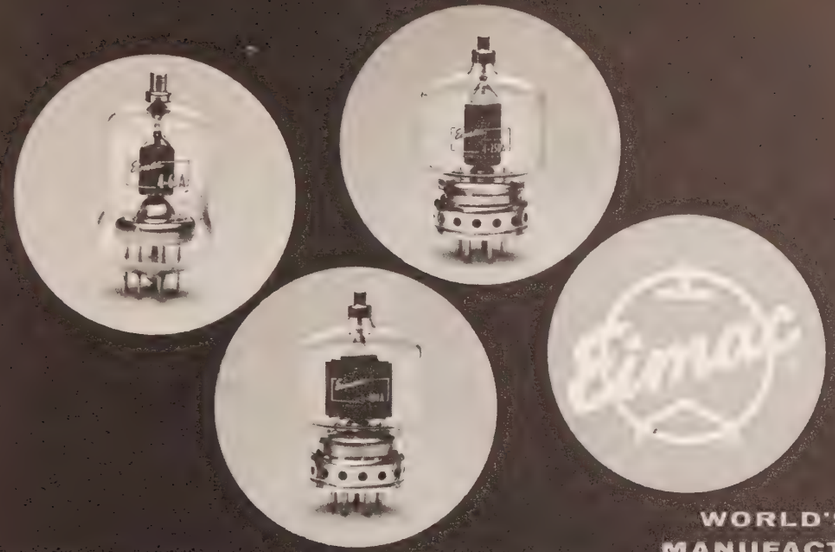
Their amazing reliability is due partly to Eimac's exclusive Pyrovac plate. This outstanding internal-anode material reduces internal arcing, actually absorbs gases which might ruin tube vacuum.

In these tetrodes, low inter-electrode capacitances and low lead inductances assure stable operation at high frequencies. Their high power gain and low driving power requirements simplify driver requirement and associated circuits.

For complete technical and application data on these outstanding tetrodes, see the attached Eimac Report to Design Engineers.

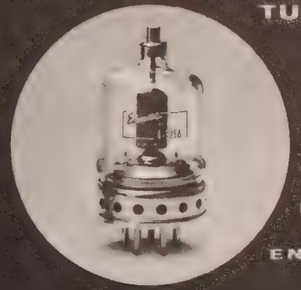
Eimac®

EITEL-McCULLOUGH, INC.
San Carlos, California



EITEL-McCULLOUGH, INC. San Carlos, California

WORLD'S LARGEST MANUFACTURER OF TRANSMITTING TUBES



REPORT TO DESIGN ENGINEERS ...FILE

REPORT TO DESIGN ENGINEERS ...FILE

EIMAC RADIAL-BEAM INTERNAL-ANODE TETRODES

Characteristics and Applications

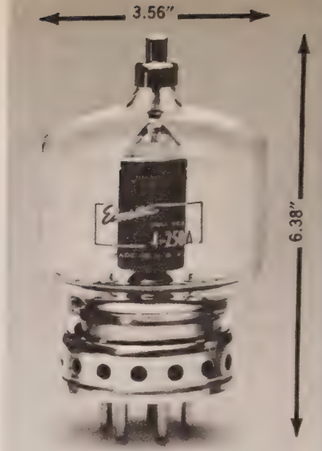
EIMAC 4-125A

125 Watt Radial-Beam Power Tetrode

The low grid-plate capacitance of this tetrode together with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage. The 4-125A is cooled by radiation from the plate and by air circulation through the base and around the envelope. It has a quick-heating thoriated tungsten filament. Highest frequency for maximum ratings: 120 Mc.

EIMAC 4-250A

250 Watt Radial-Beam Power Tetrode



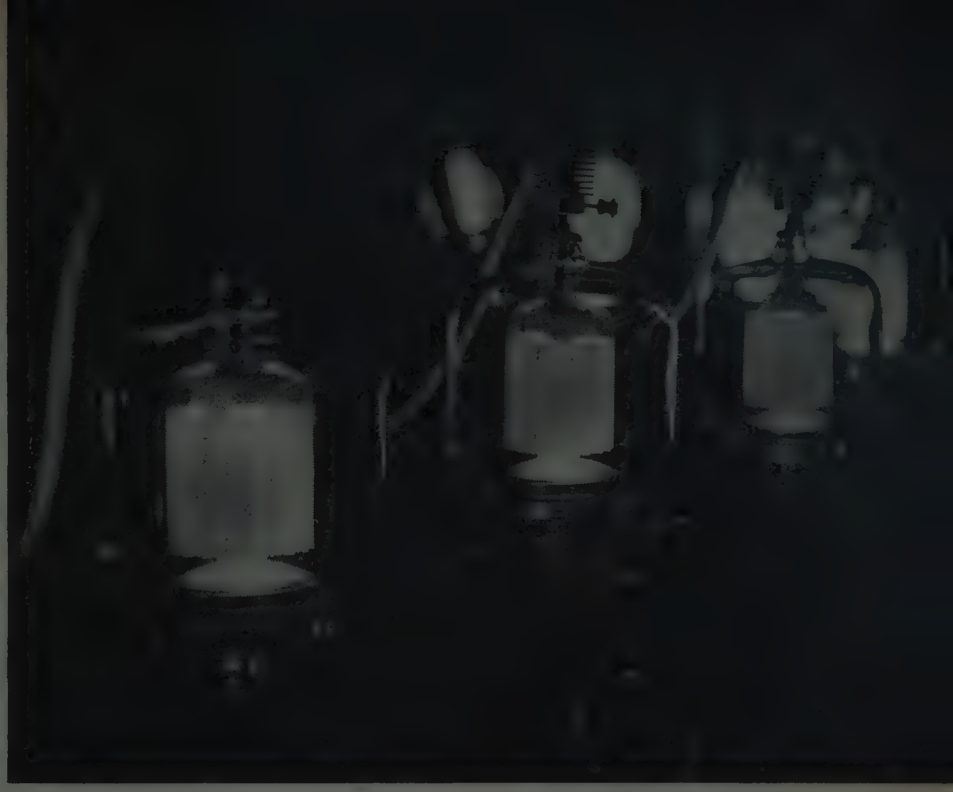
This compact, ruggedly constructed tetrode is cooled by radiation from the plate and by circulation of forced-air through the base and around the envelope. It features Eimac's exclusive Pyrovac plate, a thoriated tungsten filament, and non-emitting grid. Frequency for maximum ratings: 110 Mc.

TYPE SERVICE	FUNCTION	TYPICAL OPERATION			
		DC Plate Voltage	DC Plate Current	Driving Power	Plate Power Output
Class C Telegraphy or FM Per Tube	RF Power Amplifier and Oscillator	3,000	167 ma	2.5 watts	375 watts
Class C Telephony Per Tube, Carrier Conditions	High-Level Modulated RF Amplifier	2,500	152 ma	3.3 watts	300 watts
Class AB Sinusoidal Wave, 2 Tubes	Audio-Frequency Power Amplifier and Modulator	2,500	232 ma	0.0 watts	330 watts
Class AB Sinusoidal Wave, 2 Tubes	Audio-Frequency Power Amplifier and Modulator	2,500	260 ma	1.0 watts	400 watts
Class AB, Per Tube	RF Linear Power Amplifier SSB Single Tone	3,000	105 ma	0.0 watts	200 watts

PERFORMANCE SUMMARY

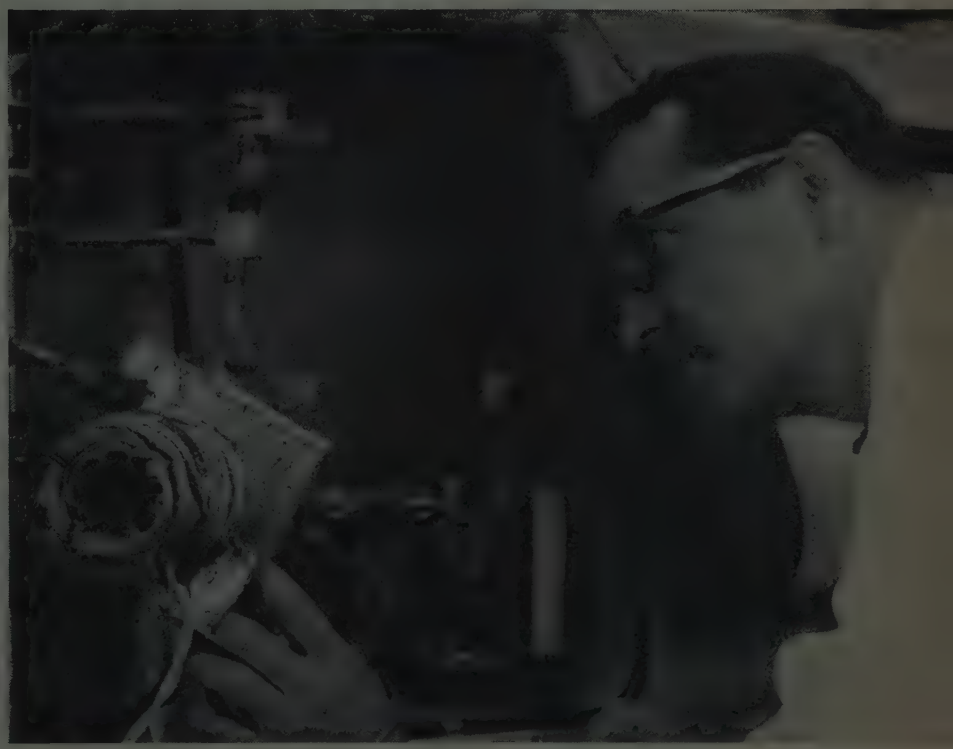
TYPE SERVICE	FUNCTION	TYPICAL OPERATION			
		DC Plate Voltage	DC Plate Current	Driving Power	Plate Power Output
Class C Telegraphy or FM, Per Tube	RF Power Amplifier and Oscillator	4,000	312 ma	2.46 watts	1,000 watts
Class C Telephony, Per Tube, Carrier Conditions	Plate-Modulated RF Amplifier	3,000	225 ma	3.2 watts	510 watts
Class AB_1 Sinusoidal Wave, 2 Tubes	AF Power Amplifier and Modulator	3,000	417 ma	0.0 watts	750 watts
Class AB_2 Sinusoidal Wave, 2 Tubes	AF Power Amplifier and Modulator	3,000	473 ma	1.9 watts	1,040 watts
Class AB_1, Per Tube	RF Linear Power Amplifier SSB Single Tone	4,000	165 ma	0.0 watts	450 watts

SEND TODAY FOR DATA SHEET GIVING COMPLETE SPECIFICATIONS, APPLICATION INFORMATION, AND TECHNICAL DATA.



CLEANER, HARDER VACUUMS INCREASE TUBE LIFE

During production Eimac-designed rotary vacuum pumps evacuate gas at high temperatures. This, plus clean electrode design and non-emitting grids, helps make Eimac internal-anode tetrodes the most reliable available.



NEWEST TUBE TYPES, TUBE IMPROVEMENTS COME FROM EIMAC RESEARCH AND ENGINEERING

First to develop internal-anode tetrodes, Eimac is also the recognized leader in ceramic-metal vacuum tubes. With emphasis on new tube types, Eimac constantly improves conventional tube types, too.

WEINSCHEL
ANTENNA PATTERN ANALYZER MODEL BA-7

Measure 45 db (r. f.) in one step using a maximum of 1 microwatt r. f. power*

*100% square wave modulated at 1000 cps ± .1 cps. Observation time approximately 45 seconds for 45 db; only .2 seconds for 30 db.

Bandwidth variable from 2 to 15 cps with constant gain

MODEL BA-7

The BA-7 is the result of a recent breakthrough in [illegible] systems designed primarily for r. f. applications. For greater sensitivity, a d. c. biasing circuit is included to permit use of conventional barretters, requiring a d. c. bias between 0 and 10 ma. The unit can be used to measure very high power ratios such as occur in making antenna pattern measurements, to determine the rejection coefficients of r. f. filters, and to calibrate attenuators. It has a wide dynamic linear range, a low noise level, and a wide r. f. frequency range where video crystal mounts are available.

For complete specifications, write for Bulletin No. 141.

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog, specifying frequency range of interest.

WE CO

Weinschel Engineering
KENSINGTON, MARYLAND

Industrial Engineering Notes*

Government and Legislative

Japanese production of electronic items in the first quarter of this year was at an annual rate of more than $736 million, or $238 million above the 1958 level, the Business and Defense Services Administration, Commerce Department, reported. In a compilation of figures based on data from the American Embassy, Tokyo, the Electronics Division, BDSA, said that Japan's electronic output for January–March, 1959 was $184.4 million, and that if this rate of activity is maintained, the 1959 totals will double the 1957 output of $362.2 million. The 1958 total was $498 million, ranking Japan as the fourth largest producer of electronic products, behind the United States, United Kingdom, and West Germany. U. S. electronics production is running at an annual rate of approximately $8.5 billion. The greatest increase in volume in Japanese production between 1957 and 1958 occurred in consumer electronic products—from $170.9 million to $266.2 million. In this category the largest increase was in the production of television receivers, from $86.8 million (0.6 million units) to $154.1 million (1.2 million units) followed by radio receivers, $67.0 million (3.6 million units) to $87.1 million (4.9 million units). These values represent factory prices plus domestic excise taxes and royalties, if any. Excise taxes are 30 per cent on television receivers with picture tubes of over 14 inches and 20 per cent on those with picture tubes of 14 inches and less. Semiconductor output registered the greatest rate of increase—129 per cent—from $10.7 million in 1957 to $24.5 million in 1958; production during the first quarter 1959 amounted to $11.5 million. The principal item in this group is transistors, of which 5.7 million units valued at $8.9 million were produced in 1957; 26.7 million units at $21.4 million in 1958; and 15.0 million units at $9.9 million in the first quarter of 1959. **The value of Japanese electronic products exported to the U. S. during the first half of this year exceeded the total for the entire calendar year 1958, The Electronics Division, Business and Defense Services Administration, Commerce Department has announced.** The BDSA Division also revealed in its compilation that these exports nearly tripled the total for calendar year 1957. Japanese exports of electronic products to this country during the January-June period this year were valued at $22.1 million, more than 50 per cent of the entire foreign market for Japanese electronic products. The value of these exports in calendar year 1958 totaled $21.775 million, or 46 per cent, and $7.582 million in calendar year 1957, or 39 per cent of market for Japanese electronics. The BDSA Electronics Division said that although consumer type radio receivers represent the largest part of this trade, other items such as recorders, electron tubes, transistors, and phonograph parts and accessories are showing "significant gains."

Engineering

The Army has released papers presented at an international symposium on image intensifiers held in October last year at Ft. Belvoir, Va., the Commerce Department's Office of Technical Services announced. The volume contains 24 technical documents read by representatives of industry and government. In the area of image converter tube intensifier research, papers deal with a two-stage electron-image converter, magnetically focused image converter tubes, a light image intensifier, the transmission secondary emission image intensifier, and image converters with protecting foils. Among papers on image orthicon devices are those on a night television system, a light scan camera tube, an image orthicon with a new target, single-layer image intensifying screens with high resolution, and daytime detection of celestial bodies using the intensifier image orthicon. The publication, "Image Intensifier Symposium," is number PB 151813, and can be ordered from OTS, Commerce Department, Washington 25, D. C., at $5 each.

Industrial Marketing Data

EIA figures released recently show an increase in radio-TV production during August, 1959, over the July level. On all counts the figures show a cumulative increase during the first eight months of this year compared with the like 1958 period. TV production in August totaled 547,445 compared with 350,360 sets made in July and 507,526 TVs made in August, 1958. This figure includes 32,847 sets capable of receiving UHF signals as against the 21,022 such sets made in July and 38,166 UHF receivers made in August last year. Cumulative UHF output during the first eight months of this year totaled 234,312 compared with 271,097 last year. Year-to-date TV output totaled 3,680,520 compared with 2,950,455 during the like January–August period last year. The number of radios produced in August totaled 1,009,423, including 279,424 automobile receivers, compared with 829,035 radios made in July including 254,725 auto sets, and 981,394 radios made in August, 1958, which included 242,915 automobile receivers. The number of FM radios made in

* The data on which these NOTES are based were selected by permission from *Weekly Reports*, issues of September 28, October 5 and 12, published by the Electronic Industries Association whose helpfulness is gratefully acknowledged.

(Continued on page 46A)

FREQUENCY STANDARDS

*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

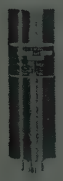
Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L

Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)



*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

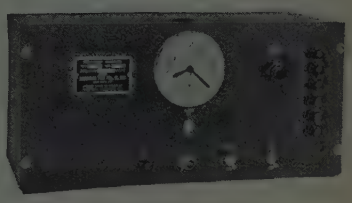
FREQUENCY STANDARD
TYPE 2005

Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

Frequencies: 50 to 400 cycles
(Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

FREQUENCY STANDARD *NEW*
TYPE 2007-6
TRANSISTORIZED, Silicon Type
Size 1½" dia. x 3½" H. Wght. 7 ozs.
Frequencies: 400 — 500 or 1000 cycles
Accuracies:
2007-6 (± .02% at —50° to +85°C)
R2007-6 (±.002% at +15° to +35°C)
W2007-6 (±.005% at —65° to +125°C)
Input: 10 to 30 Volts, D. C., at 6 ma.
Output: Multitap, 75 to 100,000 ohms

FREQUENCY STANDARD
TYPE 2121A



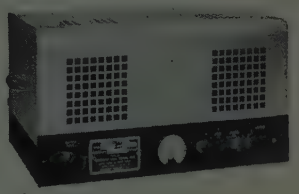
Size
8¾" x 19" panel
Weight, 25 lbs.
Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C



Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.
Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.

ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies
multi-vibrator type, 40-200 cy.
D—For low frequencies
counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

WHEN REQUESTING INFORMATION
PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

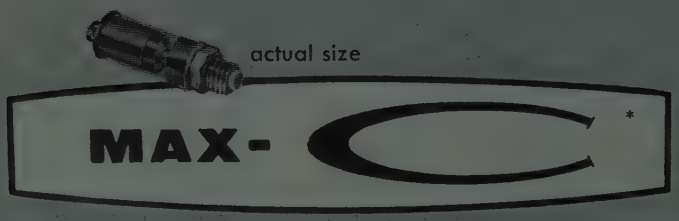
Watch Master
Timing Systems

Telephone: PLaza 7-1430

580 Fifth Ave., New York 36, N. Y.

TRIPLE THE CAPACITY
AT NO INCREASE IN SIZE

NEW FROM JFD



MINIATURE
TRIMMER
SEALCAP®

From JFD, pioneer in precision electronic components, comes the most important new miniature trimmer development in years!

Now you can have *triple* the range previously attainable in a miniature trimmer capacitor — at *no* sacrifice in volume — with new MAX-C Sealcaps.

Imagine the possibilities in your circuitry!

This new series incorporates revolutionary new advances in trimmer production which combines the advantages of a thin dielectric gap with the structural strength and ruggedness of a heavy wall glass tube. The result is a broad capacitance tuning range at a *300 per cent* saving in volume over other presently available piston trimmer caps.

Also, MAX-C Sealcaps feature a new sealed interior construction that locks out all atmospheric effects, locks in stable performance under critical extremes of altitude, vibration, shock, temperature and other rigorous environmental conditions.

These new trimmers along with the complete JFD line of miniature and subminiature trimmers, and LC tuners offer you new dimensions in design. For complete data, write today for bulletin #221.

MINIATURE PANEL MOUNT MAX-C SEALCAP SERIES

Model	Min. Max. (Pf)	DISTANCE BEYOND PANEL	MAXIMUM DIAMETER
MC601	1.0 14.0	29/64"	5/16"
MC603	1.0 28.0	11/16"	5/16"
MC604	1.0 42.0	29/32"	5/16"
MC606	1.0 60.0	1 5/32"	5/16"
MC609	1.0 90.0	1 3/4"	5/16"

Also available in printed circuit lug and lead, and 4 wire lead type.

JFD

Pioneers in electronics since 1929

ELECTRONICS CORPORATION

1462 62nd Street, Brooklyn, New York

JFD International, 15 Moore Street, New York, New York

JFD Canada Ltd., 51 McCormack Street, Toronto, Ont., Canada

TRADEMARK

Smaller filters ease the squeeze!

Filter designers! First 160-mu moly-permalloy powder cores pack high performance into smaller space

Filter and inductor designers specify our 160-mu moly-permalloy powder cores for low frequency applications. Where space is precious, such as in carrier equipment and telemetering filters, the high permeability of these 160-mu cores eases the squeeze.

In many cases, 160-mu cores offer designers the choice of a smaller core. In others, because inductance is 28 percent higher than that of 125-mu cores, at least 10 percent fewer turns are needed to yield a given inductance.

If Q is the major factor, 160-mu cores permit the use of heavier wire with a resultant decrease in d-c resistance.

Like all of our moly-permalloy powder cores, the 160's come with a *guaranteed* inductance. We can ship eight sizes from stock, with a choice of three finishes—standard enamel, guaranteed 1,000-volt breakdown finish, or high temperature finish. Further information awaits your inquiry. *Magnetics Inc., Dept. P-78, Butler, Pa.*

MAGNETICS inc.

5x10^{-10}/Day

With Laboratory Standard JKFS-1100T

FREQUENCY STANDARDS

Fully Transistorized, with Double Proportional Control Oven

Today's most advanced design, with each unit aged in and calibrated directly with WWV at Washington, D. C. **Input:** 24 to 32V DC. **Output:** 1V into 50 ohms at 1 MC and 100 KC. **Dimensions:** 6.0"H x 4 13/16"W x 12 1/2"D. **Power Supply Unit:** operates from 115V AC, with 12-20-hour self-contained stand-by batteries. Fully automatic switch-over. Dimensions: 6.0"H x 3 5/16"W x 12 1/2"D. Write for literature on JKFS **1100T**

THE JAMES KNIGHTS COMPANY, Sandwich, Illinois

from **DALOHM**
better things in smaller packages

DALE PRODUCTS, INC.
1302 28th Ave.
Columbus, Nebraska

- Precision Resistors—wire wound, metal film and deposited carbon
- Trimmer Potentiometers
- Resistor Networks
- Hysteresis Motors
- Collet-Fitting Knobs

write for Full Line Brochure

crimp-type, snap-locked contacts

Modular
HYFEN®
connector
feed-thru, multiple insert

Makes possible the design of lighter and more compact equipment. Each insert holds 35 contacts. Frames available for 5 or 8 inserts.

BURNDY

For complete information, write: **OMATON DIVISION, BURNDY**—Norwalk, Connect.

59-I

Industrial Engineering Notes

(Continued from page 42A)

August totaled 42,886 compared with 24,553 made in July and 21,335 made in August, 1958. Cumulative FM radio output during the first eight months of this year totaled 290,862 compared with 134,653 during the like 1958 period. Cumulative over-all-radio output during the first eight months of this year amounted to 8,946,044 including 3,434,345 automobile receivers, compared with 6,193,529 radios made during the like 1958 period, which included 1,893,813 auto receivers.

Military Electronics

Both military and commercial communications satellites "are now certainties of the Space Age," the Army's Deputy Chief Signal Officer told the Radio-Television Exectuives Society in New York in October. Gen. Earle F. Cook, principal speaker, said the present space communications programs of the nilitary departments ultimately will give us "reliable global communications" so "desperately needed." Gen. Cook outlined the following "ambitious" program which he said would take from 5 to 10 years to complete successfully; (all a part of Project NOTUS which constitutes a family of several kinds of communications satellites): 1) The first phase of the NOTUS Project, he said, is Task COURIER—to provide vitally needed expansion of trunking capacities for global communications by means of delayed-repeater satellites. In this concept, an Army-developed communications satellite will initially be placed in a circular orbit at a relatively low altitude of about 650 miles minimum. 2) Another task of Project NOTUS, Gen. Cook said, is to provide a real-time or instantaneous satellite repeater for two-way communications in the polar regions. This is called Task STEER, and is being developed by the Air Force. 3) A more advanced type of 6-gour polar satellite is also under development by the Army, known as Task TACKLE. It will provide ground-to-air and ship-to-shore two-way communications and will be launched in a polar orbit by an Air Force modified ATLAS missile. 4) Task DECREE is a real-time communications relay station aboard a satellite in a 24-hour equatorial orbit. The satellite operates at about 23,300 statute miles above the earth's surface and at such speed that the rotation of the earth will keep the space vehicle in a fixed position with respect to the earth. When completed, Gen. Cook said, these developments will place us "on the threshold of a vast new era of communications."

Use your IRE DIRECTORY! It's valuable!

...High Speed Switches

Philco's full range of silicon high speed switching transistors, in both PNP and NPN types, provides the designer with a wide choice to meet the requirements of all high temperature applications. They are engineered and specified to permit simple, straightforward design of practical circuits up to 5 mc pulse rates, using saturated configurations and up to 30 mc pulse rates with non-saturating techniques. Packaged in TO-1, TO-5 and TO-9 cases.

PNP 2N496 2N1119 2N1429 **NPN** 2N1199

...High Frequency Amplifiers

Philco amplifying transistors are available in nine types, covering the complete high frequency range. The designer will find both PNP and NPN types that permit the design of communications systems at frequencies up to 60 mc. They have low collector capacitance and are available with restricted beta ranges to simplify design problems. All offer excellent performance at junction temperatures up to +140°C. Packaged in TO-1, TO-5 and TO-9 cases.

PNP 2N495 2N1118 2N1428 **NPN** 2N1267 2N1268 2N1269 2N1270 2N1271 2N1272

All types environmentally tested in accordance with MIL-T-19500A . . . and have been thoroughly field-proven in countless critical military and industrial applications. **For complete data and application information, write Dept. IR-1259**

All Types Immediately Available in Production Quantities . . . and 1-99 from your local Philco Industrial Semiconductor Distributor

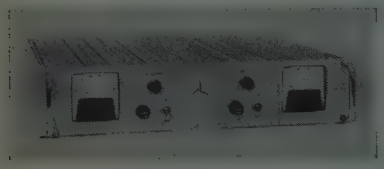
PHILCO®

LANSDALE DIVISION • LANSDALE, PENNSYLVANIA

NEWS New Products

Transistorized Power Supply

Trygon Electronics, Inc., Pleasant Ave., Roosevelt, L.I., N. Y., announces the availability of the "300" Silver Trygon Series of transistorized power supplies. This series furnishes 110 volts dc to 325 volts dc variable output at 200 ma, 400 ma, 800 ma and 1500 ma with 0.1% load and 0.1% line regulation, thus supplying transistorized power heretofore serviced by vacuum tube or hybrid equipment. The solid state design results in smaller and lighter supplies, dissipating less heat and providing high reliability.



The 200 ma, 400 ma and 800 ma, units occupy $3\frac{1}{2}$" of panel height and require convection cooling. The 1500 ma supply has a $5\frac{1}{4}$" panel height and employs forced air cooling.

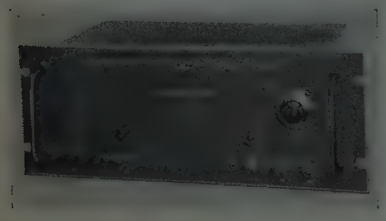
Remote programming is provided on all units, thus making them suited for automatic check out system applications.

Remote error signal sensing capabilities are provided with all units in order to maintain the voltage regulation at the load.

Units are available from stock with prices ranging from $395 to $685.

Frequency Standard

Model NC-1200, a new transistorized frequency standard, has been announced by **National Company, Inc.,** Malden, Mass.



Model NC-1200 uses a transistorized crystal oscillator identical with the one used in the most advanced models of the Atomichrom a precise frequency standard. It provides outputs of 0.1, 1.0 and 5.0 mc, all stable to one part in 10^9 parts per day. All three outputs may be used simultaneously and each is capable of developing an output voltage of 200 millivolts across a 50 ohm load.

The NC-1200 is designed for standard relay rack installation. All controls and output connections are located on the front panel. The frequency is adjustable by means of a ten turn dial which permits calibration to one part in 10^{10}.

The oscillator is designed to meet MIL-E 16,400 shock and vibration specifications. The components (oscillator, divider and power supply) can be repackaged to meet military requirements if desired.

Other specifications are as follows: size —6 by 7 by 11" box mounted on a 19 by 7" panel. Operating circuits occupy approximately 570 cubic inches exclusive of front panel. Operating weight, 15 pounds and operates from 115 volt, 60 cps ac line. Special power requirements can be provided for including battery and 400 cps ac operation.

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

Center Screwlock Connector

The **Electronic Sales Div., De Jur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N. Y., has just announced a new Series 1900 miniature rectangular power connectors with center screwlock and closed entry contacts.

These pin and socket connectors are designed for heavy duty applications. They have high dielectric and mechanical strength, and feature stainless steel channels which are riveted to the long sides of plug and receptacle.

A double lead thread action center screwlock assures positive locking action of mating units. Terminals for solderless wire wrap, solderless taper pin or solder cup are available. The closed entry contacts supplied, provide increased reliability and maintain a low millivolt drop under constant and uniform insertion pressure. In addition to the 152-contact type illustrated, this series can also be supplied with 104, 78, or 34 contacts. Body material is molded from glass filled diallyl Phthalate (MIL-M-19833, Type GDI-30).

For a free technical brochure with complete specifications and outline drawings on Continental Connector's new Series 1900, write to the firm.

Stone Named Chief Of Production At P&B

C. Robert Stone has been named chief production engineer at **Potter and Brumfield** Division of American Machine & Foundry Co., Princeton, Ind., according to an announcement today by H. L. Huntsinger, P&B executive vice-president.

The appointment, part of a program to strengthen and better integrate P&B's engineering service, gives Stone responsibility for all facets of production engineering including tooling, methods, processing, equipment development, and quality assurance. Four new production engineers will be added to his staff. They will function as project engineers and will be assisted on a staff basis by the tooling and processing groups.

Stone was graduated from Indiana Technical College, Fort Wayne, in 1950 with a Bachelor of Science Degree in Electrical Engineering. He started his career with P&B as a production foreman that same year.

Capacitor Bulletin

Wet-Slug Tantalytic® Capacitors—Bulletin GEA-7008, prepared by **General Electric Co.,** Schenectady 5, N. Y., 4 pages, provides detailed information about wet-type, sintered porous-anode tantalum capacitors used where extremely high capacitance values are required in the smallest possible space.

The publication explains performance characteristics and advantages of the units and includes 4 tables, 5 graphs, outline drawings and complete ratings and dimensions.

Volt-Ammeter Bulletin

Hook-On Volt Ammeter—Bulletin GEA-6292C, (four pages)—gives description, specifications and construction details of General Electric's pocket-size, hook-on volt ammeters for testing ac voltages. Lists applications, current ranges, accuracy percentage and operating instructions. For a copy contact **General Electric Co.,** Schenectady 5, N. Y.

(Continued on page 96A)

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 1, No. 5

NEW RAYTHEON MICROWAVE TUBE DEVELOPMENTS

Miniature pulsed magnetrons for missile beacon applications are ruggedly constructed with integral magnets. The RK-7461 is tunable from 9,300 to 9,500 mc and has minimum peak power output of 60 watts. It is 1¼" in diameter and 2½" long, and weighs only 6 ounces.

RK-7461 QK-735

The QK-735 is tunable from 5,400 to 5,900 mc with minimum peak power output of 400 watts. 1½" in diameter and 3¼" long, it weighs 8 ounces.

* * *

Designed for electronic countermeasures and FM/CW operations, the QK-625 BWO provides a minimum CW power output of 180 watts and a nominal CW power output of 250 to 350 watts over the 2,500 to 3,000 mc band. The tube is voltage tunable over the entire range with tuning sensitivity of approximately 0.4 mc/volt. Liquid-cooled, the QK-625 BWO is equipped with an integral

permanent magnet, and can be mounted in any position.

* * *

Small-signal gain of up to 35 db in microwave relay links is achieved by means of a new compact traveling wave tube amplifier -- the QK-542. This permanent-magnet focused CW tube has nominal saturated power output of 5 watts over 5,900 to 7,400 mc. An integral UG 344/U waveguide-type flange is supplied as standard. With an optional coaxial output coupler the QK-542 covers 4,000 to 8,000 mc.

Ideal for linear accelerators and high-power radar systems. The QK-783 and QK-622 Amplitrons operate over the 2,700-2,900 mc and 2,900-3,100 mc bands, respectively, at a peak power of 3 megawatts and a typical efficiency of 75%. Because no heater is required, these tubes are capable of exceptionally long life. RF gain is 8 db under rated conditions, and as high as 12 db at lower peak power outputs. Phase pushing figure is less than 0.5 degrees for a 1% variation of anode current.

* * *

Compiled as a Raytheon service to the field, new Consolidated Data Booklet contains comprehensive information about principal unclassified magnetrons, klystrons, backward wave oscillators and special purpose tubes manufactured by Raytheon. Characteristics presented include maximum ratings, typical operating values, band or frequency ranges and other essential data for microwave engineers and purchasing departments.

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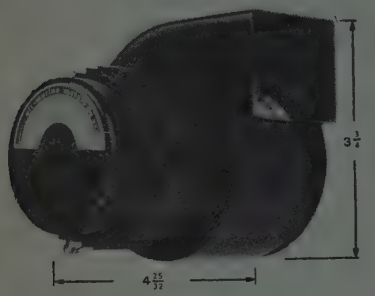

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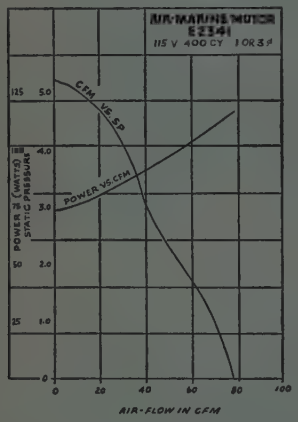

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LOS ANGELES, CALIF.

IRE People

John J. Guarrera (S'42–A'44–M'55–SM'56), engineering management specialist, has been appointed Director of Marketing and Product Development for Burton Instruments, a division of Burton Manufacturing Co. of Santa Monica, Calif., according to an announcement by William Arthur Mendelsohn, President. Mr. Guarrera was formerly associated with Reeves Instrument Corp. and Canoga Corp.

J. J. GUARRERA

He will supervise marketing of Burton's line of aircraft instruments and calibration and associated maintenance equipment, and also guide the development of new Burton instruments, test equipment, and transducers for the electronic and missile industries.

Mr. Guarrera has been a chairman of the San Fernando Valley Subsection and has served on several IRE Committees.

❖

Applied Technology, Inc., Palo Alto, Calif., has announced the election of **Dr. Oswald G. Villard, Jr.** (S'38–A'41–SM'51–F'57), senior professor of Stanford University's Radio Propagation Laboratory, to the board of directors.

He has been on the Stanford electrical engineering faculty since 1939, except for four years, 1942 to 1946, on the engineering staff of Harvard University's Radio Research Laboratory. He obtained the A.B. degree from Yale University, and subsequently the degree of Engineer and Ph.D. from Stanford. He has become well-known for his work in radio studies of the upper atmosphere since 1941–1942, when he directed ionosphere research at Stanford for the National Defense Research Committee.

Dr. Villard is a member of the American Institute of Electrical Engineers and the International Scientific Union.

❖

Dr. Arthur A. Oliner (M'47–SM'52), research professor of electrical engineering at the Polytechnic Institute of Brooklyn, left for Japan on October 17, 1959, as an invited guest of three Japanese scientific societies. The visit is sponsored by the U. S. Air Force.

During his month-long visit, which ended November 20, he lectured on the most recent developments in microwave electronics before the Japanese Institute of Electrical Engineers, the Institute of Electrical Communication Engineers of Japan, and the Tokyo Section of the Institute of Radio Engineers.

In addition to lecturing, he visited Japanese electronics laboratories to study the state of electronics developments in that country.

He lectured at universities and scientific installations in Tokyo, Sendai, Sapporo, Osaka and Kyoto. After leaving Japan he spent approximately a week in Taiwan (Formosa) to study the state of the electronics art in that country.

Dr. Oliner received his Ph.D. from Cornell University in 1946. Between 1941 and 1945 he was a graduate teaching assistant and a research assistant at Cornell. Since that time he has been a professor of electrical engineering at the Polytechnic and a research section head in Polytechnic's Microwave Research Institute.

❖

Frederick R. Lack (A'20–F'37) former EIA Vice President and Director and Vice President of Western Electric Co. until his retirement in 1958, has been elected Director of the EIA Engineering Department, accordlng to an announcement by President D. R. Hull. Mr. Lack will fill the position occupied for 25 years by Dr. W. R. G. Baker who will continue his advisory role to the Association as Director Emeritus of the EIA Engineering Department.

The election of Mr. Lack by the Board of Directors was effected by mail ballot. By virtue of his office, he becomes an ex-officio member of the Board.

He was one of the leaders in establishlng the Military Products Division in EIA and was awarded the 1959 EIA Medal of Honor last May at the Association's annual convention in Chicago for his many contributions to the advancement of the electronic industry.

Following service as a Lieutenant in the U. S. Army Signal Corps in France during World War I, he received the B.S. degree (magna cum laude) from Harvard University in 1925. He was given an honorary degree of Doctor of Science by Albright College in 1908.

During World War II he served in Washington as Director of the Army-Navy Electronics Production Agency. In 1947 he was awarded the Presidential Certificate of Merit "for outstanding fidelity and meritorious conduct in aid of the war effort against the common enemies of the United States and its Allies in World War II." In 1922 the Order of the Rising Sun was bestowed on him by the Japanese Government.

From 1925 to 1938 he was on the staff of Bell Telephone Laboratories. He later was in charge of vacuum tube development and also directed the design and

(Continued on page 52A)

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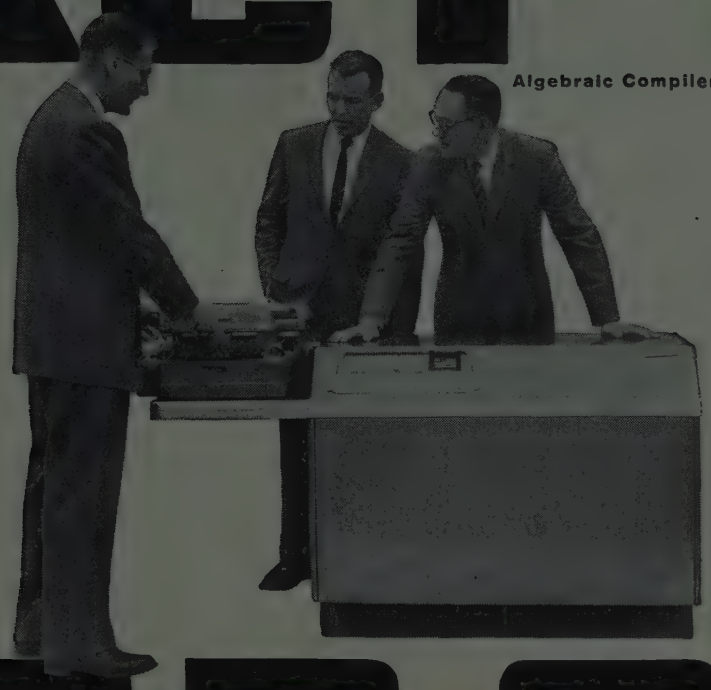

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Capable of compiling a fixed and/or floating point program for the LGP-30, ACT 1 vastly reduces programming time, gives you final solutions *faster than ever!* It is by all odds the simplest compiler to learn *and* to use.

We will be happy to send you the ACT 1 compiling routine free of charge. Write today to Royal McBee Corporation, Data Processing Division, Port Chester, New York.

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For complete information on the LGP-30 write **ROYAL McBEE CORPORATION,** data processing division, Port Chester, New York

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KOVAR is an iron-nickel-cobalt alloy developed by Westinghouse to match the thermal expansion curves of several hard glasses and ceramics. It forms an oxide bond with hard glass and is readily brazed to metallized ceramics to form a permanent vacuum and pressure-tight seal that will withstand severe conditions of temperature, vibration and handling. KOVAR can be easily welded, brazed, soldered, or plated with other metals.

Fabrication of KOVAR alloy is a specialty of Carborundum's Latrobe Plant. Equipment is available for handling almost any requirement. In addition, technical service is offered for the solution of special problems of processing and application. Contact the Carborundum Company, Reractories Division, Dept. PI-129, Latrobe Plant, Latrobe, Pa.

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IRE People

(Continued from page 50A)

building of the first commercial ship-to-shore radio telephone, installed on the liner SS Leviathan. More recently, Mr. Lack undertook the administration of the development and manufacture of the Western Electric Co.'s well-known NIKE family of missiles, many of which have been guarding the nation's cities for over five years. Among his last work on the NIKE before his retirement was with the Army on the development of the NIKE-ZEUS anti-missile missile.

Mr. Lack has been President of the American Standards Association and a director of the Armed Forces Communications and Electronics Association. He is a member of the American Institute of Electrical Engineers, the American Association for the Advancement of Science, the American Physical Society, and the Harvard Engineering Society.

❖

H. Myrl Stearns (S'39–A'40–SM'48–F'59), president of Varian Associates, has been elected a Fellow of the American Association for the Advancement of Science.

One of the founders, in 1948, of Varian Associates, he has been a key figure in the development of the electronics industry on the west coast. He has served as director of the San Francisco section and chairman of the Palo Alto subsection of the IRE. He is active in affairs of the Western Electronics Manufacturers Association, having served the group as president in 1955. As 1959 chairman of the board of directors for WESCON, he presided at the association's recent convention in San Francisco. Mr. Stearns also is a past vice-chairman for the west of the American Institute of Electrical Engineers.

❖

George G. Young (SM'56) has been appointed Manager of the Production Engineering Subsection of General Electric Co.

He received the B.S. degree in electrical engineering from North Carolina State College in 1942, and immediately following graduation he joined General Electric's engineering test program at Schenectady, N. Y. In 1942 he transferred to Bridgeport, Conn., where he was associated with the then combined General Electric radio and television department. He came to Syracuse as a production engineer on FM radio receivers when the department was moved to Electronics Park. In 1952 he was named supervisor of production engineering for television receivers.

Mr. Young is a member of Eta Kappa Nu.

❖

M. E. Femmer (A'48–SM'53), formerly Associate Director of Research for IBM at the Lamb Estate Research Laboratory,

(Continued on page 56A)

Signals from Space

A boy can now hear sounds that you were able to hear only in your dreams. Today a boy can actually hear signals from space! A tiny beacon (left) has been developed by Melpar to ride far above the earth, sending back tales of achievement from missiles and satellites. IMAGINEERING at Melpar will turn many of your dreams into realities. Because Melpar is constantly expanding its capacity for original conception, design, and production of advanced defense and space exploration projects.

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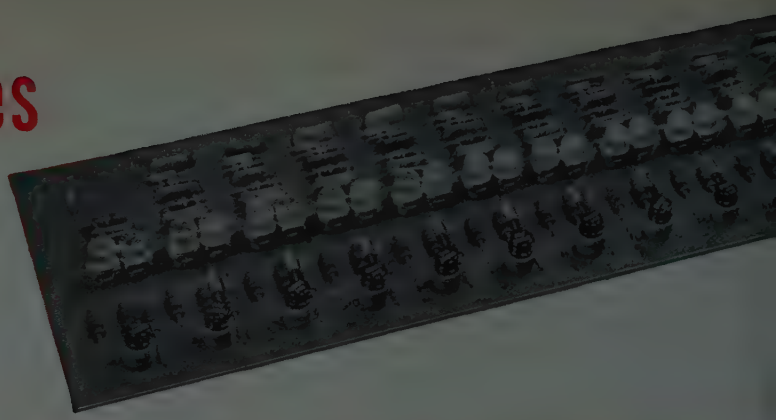
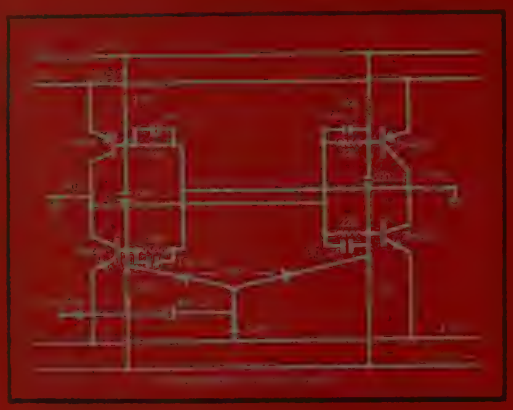
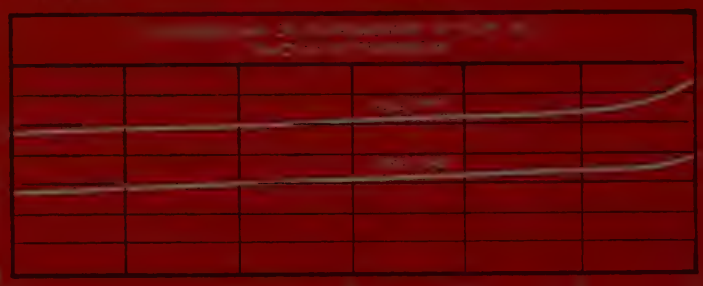


COMPLEMENTARY FLIP FLOP CIRCUIT





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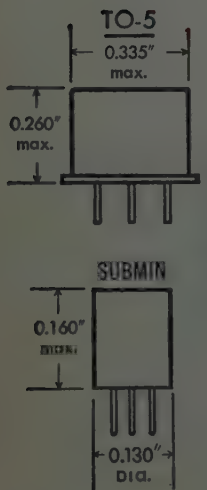

GERMANIUM PNP ALLOY — TO-5 CASE

Type	V_{CE} Volts	$f_{\alpha b}$ Avg. Mc	H_{FE1} I_B = 1MA V_{CE} = 0.25V	H_{FE2} Min. I_B = 10MA V_{CE} = 0.25V	Rise* Time Max.
2N404	−24	12	—	—	—
2N425	−20	4	20–40	10	1.0
2N426	−18	6	30–60	10	0.55
2N427	−15	11	40–80	15	0.44
2N428	−12	17	60	20	0.33
2N1017	−10	22	80	20	0.27

*I_C = 50MA; I_{B1} = 5MA; R_L = 200Ω I_{B2} = 5MA

GERMANIUM NPN ALLOY — TO-5 CASE

Type	V_{CE} Volts	$f_{\alpha b}$ Avg. Mc	H_{FE} Min. I_C = 50MA V_{CE} = 1.0V	Rise** Time Avg. μsec
2N438	25	6	20	0.7
2N439	20	11	30	0.5
2N440	15	17	40	0.3

**I_{B1} = I_{B2} = IMA; I_C = 10MA; R_L = 1KΩ

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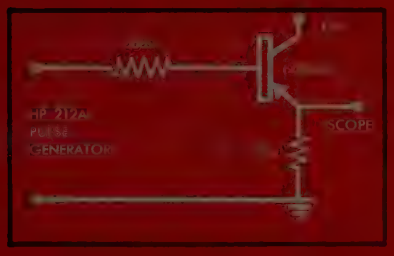

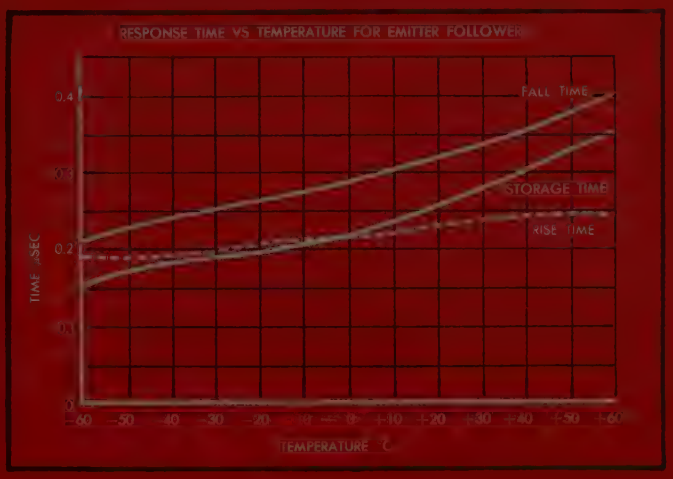

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High Current Switches

GERMANIUM PNP ALLOY — TO-5 CASE

Type	V_{CE} Volts	$f_{\alpha b}$ Avg. Mc	H_{FE1} $I_B = 1MA$ $V_{CE} = 0.25V$	H_{FE2} Min. $I_B = 10MA$ $V_{CE} = 0.35V$
2N658	−24	5	25–80	15
2N659	−20	10	40–110	25
2N660	−16	15	60–150	40
2N661	−12	20	80	55
2N662	−16	8	30	18

Subminiature Switches

GERMANIUM PNP ALLOY — SUBMIN CASE

Type	V_{CE} Volts Volts	$f_{\alpha b}$ Avg. Mc	H_{FE1} $I_B = 1MA$ $V_{CE} = 0.25V$	H_{FE2} Min. $I_B = 10MA$ $V_{CE} = 0.35V$	Rise* Time Max.
CK25	−20	4	20–40	10	1.0
CK26	−18	6	30–60	10	0.55
CK27	−15	11	40–80	15	0.44
CK28	−12	17	60	20	0.33

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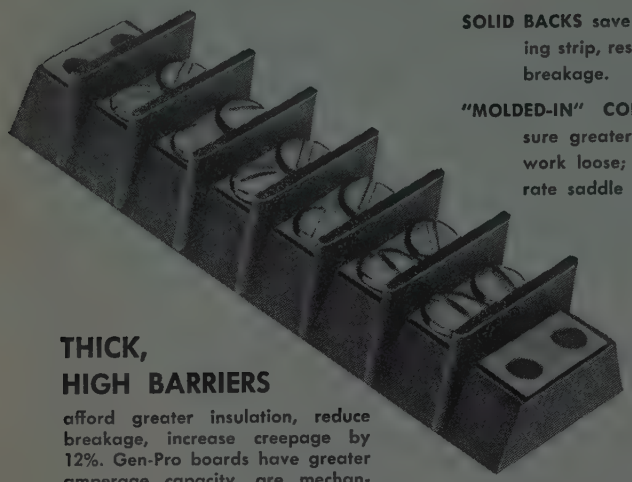

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PRINTER RELAY
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Pace-Setters in Quality Communication Equipment
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Write on your letterhead for free literature to Dept. P-12.

IRE People

(Continued from page 52A)

M. E. FEMMER

located in Cortlandt, N. Y., has been appointed Manager, Engineering Plans, on the staff of the Vice President—Research and Engineering in the Corporation offices at 590 Madison Avenue, New York, N. Y.

In his new position, he will exercise staff supervision over engineering and product development activities throughout the corporation.

He joined IBM in August, 1946, as a laboratory engineer working on the design of a matrix multiplier and on RF gas tube research for a matrix multiplier. He was later appointed a technical engineer and in July, 1949, became a project engineer working on magnetic tape systems development. In this assignment he helped develop electronic circuits for reading, writing and control of the first IBM prototype tape drive and associated systems. Later he worked on the outline and design of high speed I/O circuits and systems for the NORC computer including coordination of the design of very high speed magnetic tape drives. In April, 1951, he was placed in charge of the overall I/O design for the IBM 701 computer. From that time until September, 1952, he was assigned projects of increasing responsibility including training a group of graduate engineers for temporary field service with the first 701 computer systems, and final engineering changes on the 701 model. In May, 1953, he was assigned to report to R. L. Palmer as staff assistant on all Poughkeepsie engineering programs. In September, 1954, he was appointed development engineer and served as assistant manager and subsequently manager of all EDPM engineering. In this capacity he was responsible for all EDPM engineering development programs. He was appointed Associate Director of Research in March, 1956, and in Septenber, 1956, was assigned to report to Dr. E. R. Piore, Director of Research.

Mr. Femmer holds the B.S. degree in electrical engineering from the University of Missouri. He entered the Army in 1943 and upon discharge to inactive duty in July 1946 was a first lieutenant. He is a member of the Association for Computing Machinery and Eta Kappa Nu, and a life member of Tau Beta Pi.

❖

Carl D. Bethel, Jr. (M'46–SM'52) has been elected vice president of Mackay Radio and Telegraph Company, it was announced by B. B. Tower, president of American Cable & Radio Corp. AC&R, an ITT associate, is Mackay Radio's parent company.

A graduate of Pennsylvania State

(Continued on page 62A)

Electron Tube News —from SYLVANIA

New designs to meet new demands—everywhere in electronics

LOW HEATER POWER CATHODE-RAY TUBES...

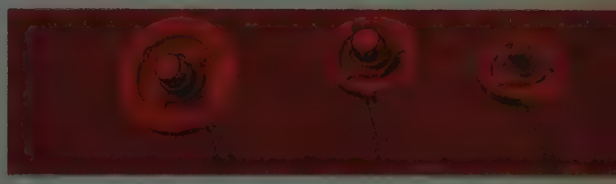
Low Heater Power CRT's use 1.5 v supply compared to 6.3 v for ordinary tubes

New 1.5 volt, 140 ma heater for CRT's under development at Sylvania will add new portability to oscilloscopes, radar and TV

Another revolutionary advance in cathode-ray tube design is now in final stages of experimental development at Sylvania's Industrial & Military Cathode-Ray Tube Department—Low heater power CRT's. The new 1.5 volt, 140 ma heater design requires less than 1/16 the power of ordinary CRT's—or less than ¼ watt compared to 4 watts. This not only means highly significant reductions in power supply requirements with the 210 mw heater but significant reductions in cooling requirements. As a result, new design approaches will be opened for portable oscilloscopes, portable radar, portable transistorized TV, missiles and any other application where minimum power supply weight and size are important considerations.

Your Sylvania equipment sales representative will be glad to discuss specific applications and sample availability with you.

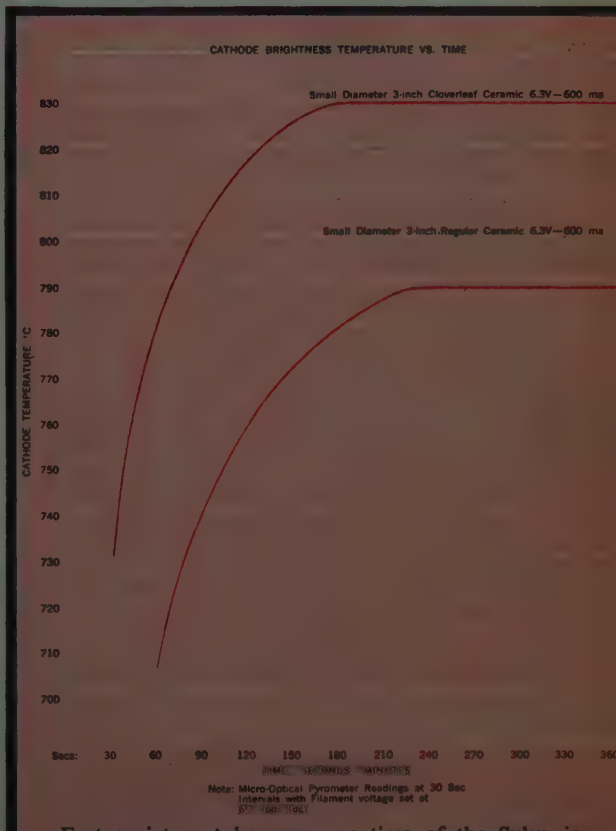
CLOVERLEAF CATHODE ASSEMBLY DESIGN...



"Cloverleaf" ceramic cathode assembly design, now available in all new Sylvania picture tubes, assures faster warm-up time throughout tube life

Already proved in hundreds of thousands of picture tubes is the Sylvania Cloverleaf cathode assembly. Its unique ceramic Cloverleaf configuration greatly reduces heat conduction losses and nearly doubles TV warm-up speed by reducing cathode-ceramic disc contact area. This not only increases assembly ruggedness but contributes to the overall efficiency of the tube.

Sylvania Cloverleaf is now available in all new TV picture tubes ranging from 110° 300 ma types to 72° 600 ma types as well as some industrial and military cathode-ray tubes. Contact your Sylvania representative for the full story on Sylvania Cloverleaf.



Faster picture tube warm-up time of the Sylvania Cloverleaf Cathode assembly shows up in this comparison of it with a conventional cathode assembly

INDUSTRIAL & MILITARY CATHODE-RAY TUBES...

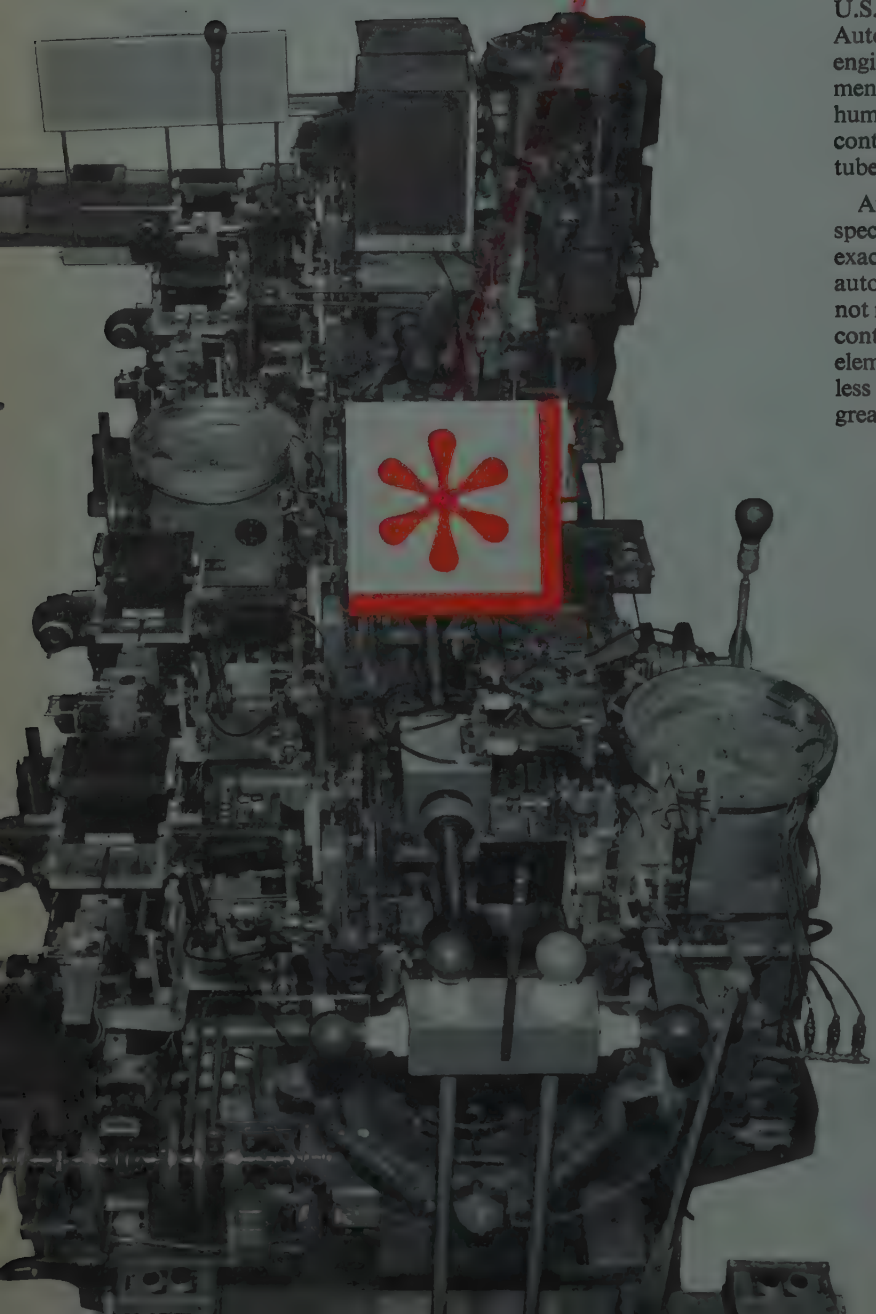
Today, Sylvania's Industrial and Military Cathode-Ray Tube department is producing over 150 tube types to meet the specialized needs of the growing industrial and military market. Here are the latest additions to this expanding line:

Type 4MP__series—This four-inch square face CRT is designed for use in oscilloscopes and other display devices where space considerations are important. It features electrostatic focus and deflection as well as post deflection acceleration. Its deflection plate leads are sealed through the neck . . . a design which assures low capacity and inductance.

Type 5BCP__series—This five-inch round oscilloscope tube is designed with a ⅞-inch neck diameter that can more effectively utilize low deflection power. It features magnetic focus and deflection.

THIS IS AUTO-MOUNT...

HEART OF SYLVANIA AUTOMATION



Now in operation in Sylvania tube plants throughout the U.S. is this intricate maze of engineering ingenuity called Auto-Mount. Designed and developed by Sylvania engineers, it automatically assembles delicate tube elements with a precision and efficiency unattainable by human hands. It represents one of the greatest single contributions to uniformity in mass-produced electron tubes ever developed.

Auto-Mount first prepunches each mica spacer with specially designed dies that achieve greater precision and exactness than heretofore possible. At the same time, it automatically checks mica thickness and rejects those not meeting its tight tolerances. This new degree of mica control not only means greater spacing precision of tube elements but tighter fit in the mica spacer. The result is less micro, reduced noise, better heat dissipation and greater overall tube efficiency.

Next, Auto-Mount delicately feeds famous Sylvania cathodes to each moving jig assembly and precisely inserts them into proper position. Then, as the assembly moves through each station, grids, plates, and finally the top mica are automatically inserted and assembled. It performs tab bending operations with exact uniformity, resulting in a tighter mount and reduced micro. Each mount undergoes multiple visual and microscopic inspections to assure quality. Any mount that does not meet Auto-Mount's stringent standards is automatically rejected.

Not only does Auto-Mount contribute to better tube performance by eliminating human errors, damage and inaccuracies, but because it requires elements of closer dimension tolerances than hand mounting, the mount it produces is inherently more uniform and rugged. This means less micro, better cutoff, less heater-cathode leakage and more uniform characteristics from tube to tube.

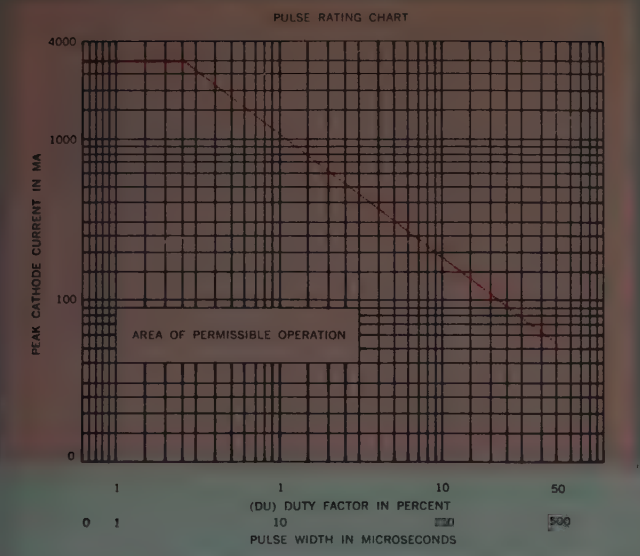
The end result is a new degree of performance perfection from Sylvania receiving tubes unmatched by any other mass-produced electron tube. Contact your Sylvania representative today for complete information on Sylvania Auto-Mount receiving tubes.

SYLVANIA

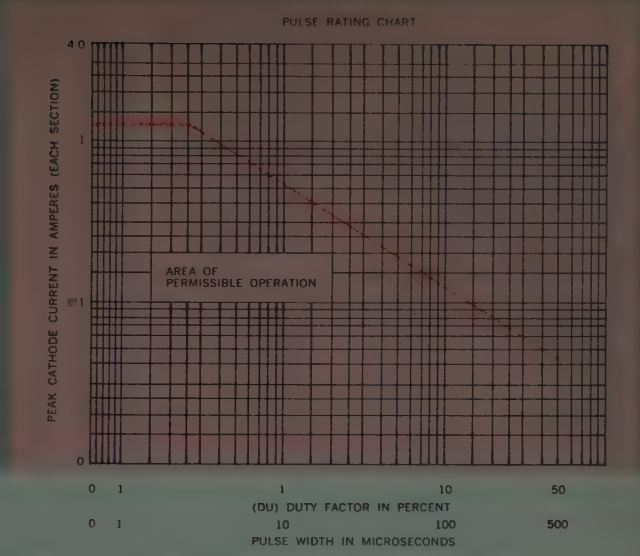
Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

TYPE GB-7550



TYPE GB-7327



Pulse Rating Charts, exclusive with new Sylvania Pulse Types, show the high current capabilities of the new tubes

PULSE TUBES . . .

Sylvania develops industry's first subminiature Pulse Tubes specifically designed for pulse amplifier and BTO circuits

Now the design engineer can select subminiature tube types specifically designed for pulse applications. Sylvania is developing a line of pulse types rated to deliver high pulse current with reliability, compactness and accuracy. No longer is it necessary to use tubes designed for other purposes that are not rated to consistently meet pulse requirements. With the new Sylvania types, higher pulse current is assured and each is supplied with a pulse rating chart. This not only makes the design problem much simpler but means better end equipment performance.

Two new pulse types GB-7327 and GB-7550 are already in full production at Sylvania with more on the way:

TYPE GB-7327—This new subminiature (T-3 bulb) medium mu double triode is specifically designed and processed for pulse applications. It features low vibrational noise and excellent performance under rugged environmental conditions. It is a direct replacement for types 6111 and 6021 and with some modification can replace any double triode. The tube, as its GB prefix indicates, is specifically designed to meet commercial and industrial application requirements. In addition, it is the first tube made by Sylvania that employs both the AQL and new Sylvania ADL quality systems. This means extra assurance that every Sylvania pulse tube will meet customer specifications effectively.

TYPE GB-7550—This is Sylvania's newest pulse type, a subminiature (T-3 bulb) double triode with a higher cathode pulse current. It can easily replace types 6111 and 6021. With varying degrees of modification, it can be used in place of any double triode. It features a larger cathode for additional current capabilities and new grid radiators for more effective dissipation. It too is a Sylvania GB type made to meet the specific requirements of industrial and commercial applications. It also incorporates both the AQL and new Sylvania ADL quality standards.

Both new Sylvania pulse types, GB-7327 and GB-7550, may be used in pulse amplifier or BTO circuits. This opens applications in areas such as: Aerial Navigation Equipment (Pulse radar and missiles) Sylvania is continuing to develop additional pulse tube types to meet increasing industry demand for accurate, dependable high-current pulses. Check with your Sylvania representative or contact the factory directly for latest information on Sylvania GB Pulse Tubes.

New Sylvania Pulse Types GB-7327 and GB-7550

Characteristics	GB-7327	GB-7550
DIRECT INTERELECTRODE CAPACITANCES (Unshielded)		
Grid to Plate	1.5 uuf	4.0 uuf
Input: g to (h+k)	1.9 uuf	4.0 uuf
Output: p to (h+k)		
Section No. 1	0.28 uuf	0.24 uuf
Section No. 2	0.32 uuf	0.28 uuf
Grid to Grid	0.011 uuf Max.	0.16 uuf Max.
Plate to Plate	0.50 uuf Max.	1.2 uuf Max.
RATINGS (Absolute Maximum Values)		
Heater Voltage 3	6.3 ± 5% V	6.3 ± 5% V
DC Plate Voltage	300 Vdc	300 Vdc
Instantaneous Forward Plate Voltage	400 V	400 V
Plate Dissipation (Each Plate)	0.95 W	2.0 W
Grid Dissipation (Each Plate)	0.2 W	3.6 W (Both Plates) 0.4 W (Each Grid)
CHARACTERISTICS RANGES (Each Section)		
Pulse Cathode Current: Ef=6.3 V; Eb=300 Vdc; Ec=−25 Vdc; egk=+50 v at tp=10 usec; prr=1000 pps; tr=0.8 usec Max.; tf=1.0 usec Max.	700 mA Min.	1400 ma Min. Ef=6.3 V; Eb=300 Vdc; Ec=−30 Vdc; Instantaneous Voltage Between Grid and Cathode (Smoothed Peak)=+40 v at tp=10 usec; prr=0.8 usec Max.; tf=1.0 usec Max.

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Buffalo 9, N. Y.

STRAP-FRAME CONSTRUCTION . . .

Sylvania introduces the strap-frame grid design in a new tetrode type 6ER5, designed as a VHF amplifier for TV tuners

Complementing the Framelok Grid design for power applications is the Sylvania strap-frame grid development for high frequency tuner type applications. First Sylvania tube incorporating strap-frame grid construction in a T-3 envelope is type 6ER5. It is a semi-remote cutoff tetrode designed as a VHF amplifier for TV tuners. It features high transconductance, high input impedance, low intermodulation distortion and dual cathode pins. Grid No. 2 functions as a shield to reduce grid to plate capacitance.

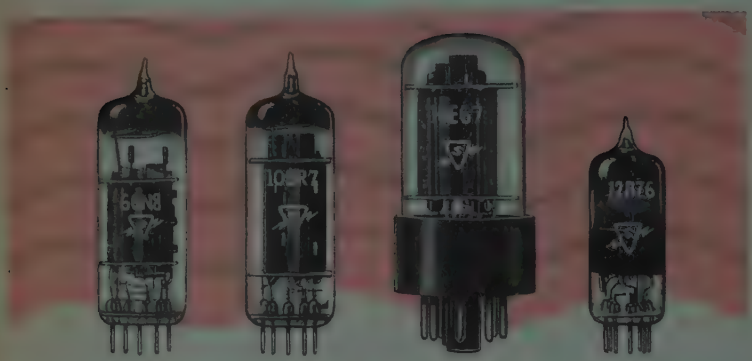
The strap frame, as its name implies, gives new extra support to grid side rods. Not only does this make a more rugged, accurately aligned grid possible, but since the grid laterals themselves do not support the rods, finer grid wire with greater TPI (turns per inch) can be used. The end result is higher gm, better dissipation and overall more efficient performance.

RATINGS (Design Center Values)

Supply Voltage	550 Volts
Plate Voltage	250 Volts Max.
Grid No. 2 Voltage	100 Volts
Plate Dissipation	2.2 Watts Max.
Grid No. 2 Dissipation	0.5 Watts
Cathode Current	20 Ma Max.
Negative Grid Voltage	50 Volts Max.
Grid Circuit Resistance	
Cathode Bias	1.0 Megohm Max.

Sylvania's new Strap-Frame high fre quency tuner type, 6ER5. Strap Frame grid construction permits us of finer grid wire for more TPI

VIDEO . . .



Five new types from Sylvania for TV service

TYPES 6GN8 AND 8GN8—Both of these new types incorporate a high mu triode and a sharp cutoff pentode in one T 6½ envelope. The triode section is designed for voltage amplifier or sync separator service. The pentode section, designed for video amplifier service, features a controlled knee characteristic.

TYPE 10DR7—Double triode in a T 6½ envelope with a high mu section for vertical deflection oscillator use, and a low mu section for use as a vertical deflection amplifier.

TYPE 10EG7—T9 double triode for series string TV with a medium mu section designed for vertical deflection oscillator use and a low mu section for vertical deflection amplifier use.

TYPE 12BZ6—T 5½ semi-remote cutoff pentode for use as an automatic gain controlled amplifier.

SYLVANIA GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd.
P. O. Box 1190, Station "O," Montreal 9

Please send additional information on the items checked below:

Industrial & Military Cathode Ray Tubes
- ☐ Type 4MP—series
- ☐ Type 5BCP—series

New Sylvania Pulse Tubes:
- ☐ Type 7327
- ☐ Type 7550

New Strap-frame Grid Tube
- ☐ Type 6ER5

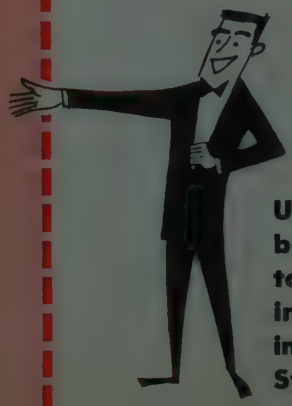
New entertainment receiving tubes
- ☐ Type 6GN8 ☐ Type 10EG7 ☐ Type 8GN8 ☐ Type 12BZ6
- ☐ Type 10DR7 ☐ Special tube designs for particular applications

Name_____

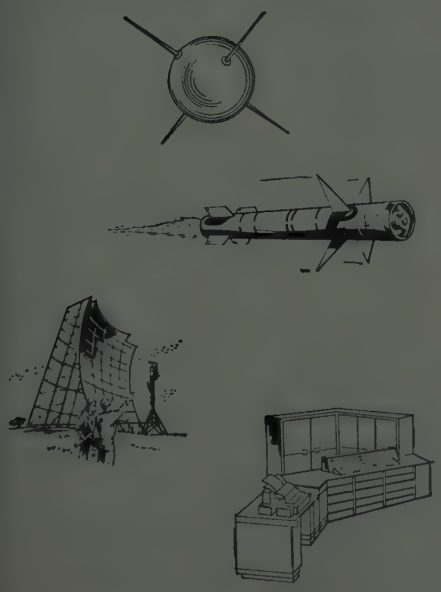
Address_____

Company_____

Code 4Q59



Use this handy business reply card to request additiona information on thes important new Sylvania developme



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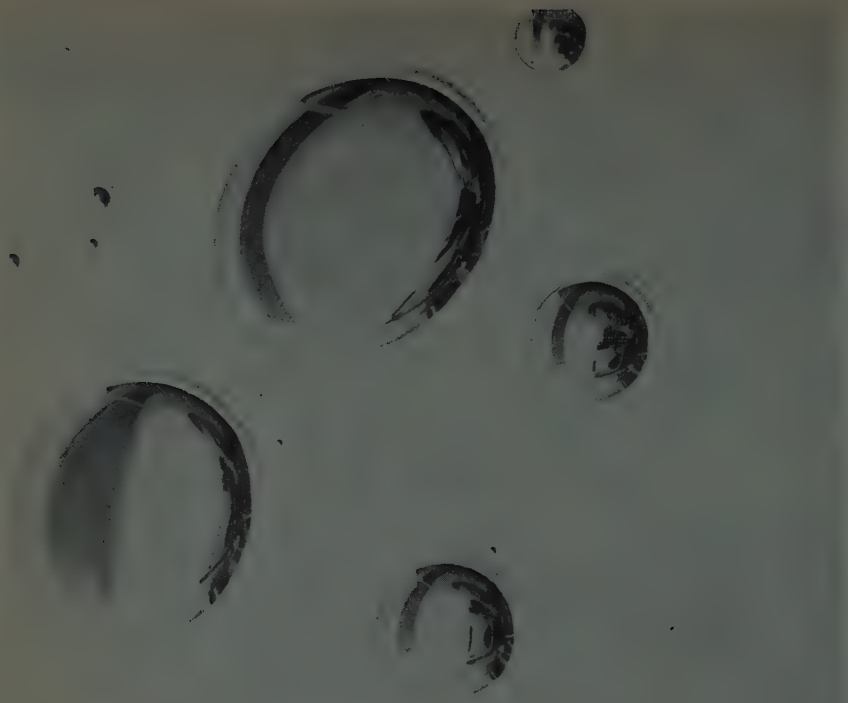

the state of the art is understated...

There is a "quicksilver" in all research and development. This elusiveness is greater in the design of microwave ferrite components than in any other electronic field. The engineer must be able to say: "It works, but not consistently enough" or "It works, but not well enough." It then becomes a matter of knowledge, patience, originality, time and testing until the device meets the necessities of its application and meets them consistently.

This immaculate attention to detail is why Rantec microwave ferrite components have their reputation as the most dependable and predictable in the field.

PHASE SHIFTERS SINGLE SIDE-BAND MODULATORS

HIGH-SPEED FERRITE SWITCHES AMPLITUDE MODULATORS

LOAD ISOLATORS ISO-DUPLEXERS CIRCULATORS

rantec corporation

calabasas, california

IRE People

(Continued from page 56A)

University, Mr. Bethel joined Mackay Radio in 1945 after serving as a U. S. army officer in Europe and North Africa during World War II. He was transferred to Manila in May, 1958, upon his appointment as district manager, and will continue to reside in the Philippines.

❖

Neal J. Dean (S'46–A'47–M'50–SM'53) has been admitted to the partnership of Booz, Allen & Hamilton, nationwide management consultants.

N. J. Dean

He was previously technical director of the firm's Electronic Data Processing Department. He has specialized and will continue to work in consultlng on data processing systems for banks, utilities and industrial firms throughout the country. He has presented more than 30 papers before various management groups and professional societies, and has authored several articles on electronic data processing.

Before joining Booz, Allen & Hamilton in 1958, he was head of the Data Processing Consulting Services for Ramo-Wooldridge Corp. Prior to that he was head of the business machines applications department of the Laboratory for Electronics, Inc., and was director of circuit research and development of the Sonotone Corp. He was director of the Electrical Measurements Laboratory of Columbia University and has lectured on engineering and electronics subjects at six universities.

Mr. Dean received the B.E.E. degree from Manhattan College in 1944 and the M.S. degree in electrical engineering from Columbia University in 1946.

❖

Aladdin Electronics, division of Aladdin Industries, Inc., has announced the appointment of **Paul E. Dicker** (S'47–A'50–M'56–SM'59) to the position of Chief Engineer.

He has been associated with Aladdin for approximately four years serving as a consultant on special technical assignments. During this period he has also held the position of associate professor of electrical engineering at Vanderbilt University.

Mr. Dicker received the B.S.E.E. from Swarthmore College in 1945. He was awarded the Master's Degree in Electrical Engineering by Ohio State University. In addition to holding other teaching positions at Ohio State and Princeton, he has done research work and design engineering in many fields of special interest to Aladdin.

❖

(Continued on page 64A)

300° C
stabilization of FAIRCHILD SILICON TRANSISTORS is a regular step

WHY?

TO ACHIEVE MAXIMUM RELIABILITY! Every completed Fairchild Transistor is stored at 300° C for at least 60 hours before final inspection. Most types would not survive. For Fairchild's Diffused Silicon Mesa Transistors, this step stabilizes parameters an equivalent of thousands of hours at 175° C. Many of our customers are verifying the resulting reliability in test programs of their own.

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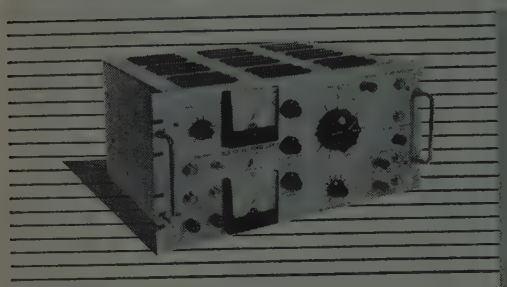
NEW IDEAS IN PACKAGED POWER

for lab, production test, test maintenance, or as a component or subsystem in your own products



Series 1000.

Easy-to-use compact Beta Series 1000 high voltage supplies come in 13 different models, providing voltages up to 60kv dc and currents as high as 500 ma. Adjustable output voltage (0 to max. rating with coarse and fine controls); extremely low ripple; easy, rapid polarity reversal and full metering are a few outstanding features.

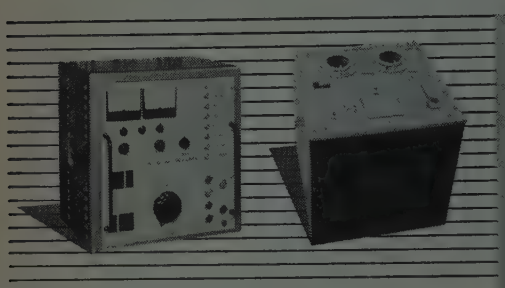
Single-unit, rack-mounting supplies to 60 KV

Available ranges and current capacities:

Output (DC KV)	Current (Max. MA)
0-1	500
0-3	200
0-5	10 or 100
0-10	2, 10, or 50
0-15	5, or 10
0-30	2, 5, or 10
0-60	5 @ 50 KV 1 @ 60 KV

Inputs: 117 vac, 60 cps, single phase

HV DC TO 250KV WITH MAXIMUM CONVENIENCE, SAFETY



Series 2000 — control section (left).
Series 2000 — high-voltage section (right).

Simple to operate, conservatively rated to insure long, optimum performance with maximum safety, Beta Series 2000 supplies come in thirteen different models, with maximum voltages ranging from 1 to 250kv dc. Output voltage continuously adjustable from 0 to maximum. Two-unit design allows optional remote operation of high voltage circuits. For maximum voltages less than 30 kv, the high-voltage unit is air-insulated; for higher voltages, oil-insulated (shipped dry). Every precaution is taken to insure personnel and equipment safety.

Two section supplies to 250KV

Available ratings:

Output (KV DC)	Current (Max. MA continuous)
0-1	3000
0-3	1000
0-6	500
0-10	200
0-20	150
0-30	30
0-30	100
0-50	10, 50
0-120	5
0-120	25
0-150	5
0-250	10

Inputs: 117 vac, 60 cps, single phase

Sorensen markets the widest line of controlled power equipment available today, including: Regulated a-c and d-c supplies, unregulated power supplies, frequency changers, inverters, and converters, SAMES electrostatic generators for regulated voltages up to 600 kv dc, voltage reference sources, high-voltage d-c overpotential testers and high-potential test equipment.

An exceptionally wide selection of standard models is available and experienced Sorensen engineers are always glad to discuss your special needs. 9.13

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IRE People

(Continued from page 62A)

Milton Magid (S'48–A'49–M'55–SM'57) has joined the FXR engineering staff as Head of Microwave Product Engineering. Prior to joining FXR, he had been associated with the Hughes Aircraft Co., Culver City, Calif. since 1949. Since November, 1953, he had been Supervisor of the "Microwave Section of the Primary Standards Laboratory."

MILTON MAGID

Mr. Magid received the B.S. degree (with honors) from the University of California at Berkeley and the M.S. degree from the University of California at Los Angeles. He has been elected to Eta Kappa Nu, Tau Beta Pi and Sigma Xi honor societies and is an Associate Member of the Scientific Research Society of America (R.E.S.A.).

❖

Arthur A. Hauser, Jr. (M'48) has been appointed to the new position of director of technical planning at Sperry Gyroscope Co., Great Neck, N. Y.

A. A. HAUSER, JR.

He has had 17 years' experience in the management of advanced research efforts. Since joining Sperry in 1942, he has directed numerous research groups in development of advanced computer techniques, air, surface, and under-sea weapon systems, industrial controls, and automated business systems. In 1957 he became responsible for coordination of the research and development activities of Sperry's many widely diversified divisions.

He holds five patents on fire control, guidance, and computer devices and is the author of numerous scientific papers on these subjects.

Mr. Hauser earned the B.S. degree in mathematics at Massachusetts Institute of Technology and the M.S. degree in mathematics at New York University. His professional memberships include the American Physical Society, Sigma Xi, Atomic Industrial Forum, and the Industrial Research Institute.

❖

(Continued on page 66A)

Make Your Plans Now!
1960 IRE SHOW
March 21-24, 1960
New York Coliseum

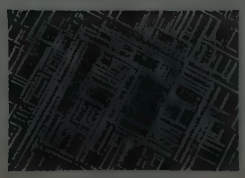
The revealing face of an iron crystal

A single crystal is an ideal system for studying the solid state. Physicists at the General Motors Research Laboratories have turned to whisker-like growths of nearly perfect single iron crystals to investigate three intriguing phenomena: magnetic domains, dislocation defects, and—more recently—high temperature oxidation.

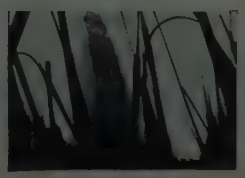
In this latest study, the two crystallographically different surfaces found on iron whiskers are being used to examine the anisotropy or axial-dependent nature of the oxidation process. In early stages of oxidation, the oxide patterns that form on clean surfaces have been found to be strongly dependent upon the orientation of the underlying crystal. In later stages of oxidation, tiny oxide "cilia" actually grow on the surface of the iron whisker. But these new whiskery forms of oxidation are no longer related to the crystal's surface arrangement. The next step in this program involves correlating the oxidation behavior with lattice structure defects such as vacancies and dislocations.

This type of solid state research is revealing the atomic processes underlying strength, magnetic characteristics, and corrosion resistance of metals. At GM Research, we believe the solution to practical problems is increasingly dependent on fundamental information such as this. And each solution enables us to continue to provide "More and better things for more people."

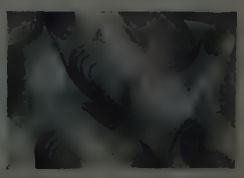
GENERAL MOTORS RESEARCH LABORATORIES



Early Oxidation



Oxide Whiskers



Reduction of Oxide Products

Versatile in Readout and Display

MULTICHANNEL DATA RECORDER

up to 1000 discrete marks (or channels) on 19 inch wide dry electrosensitive paper

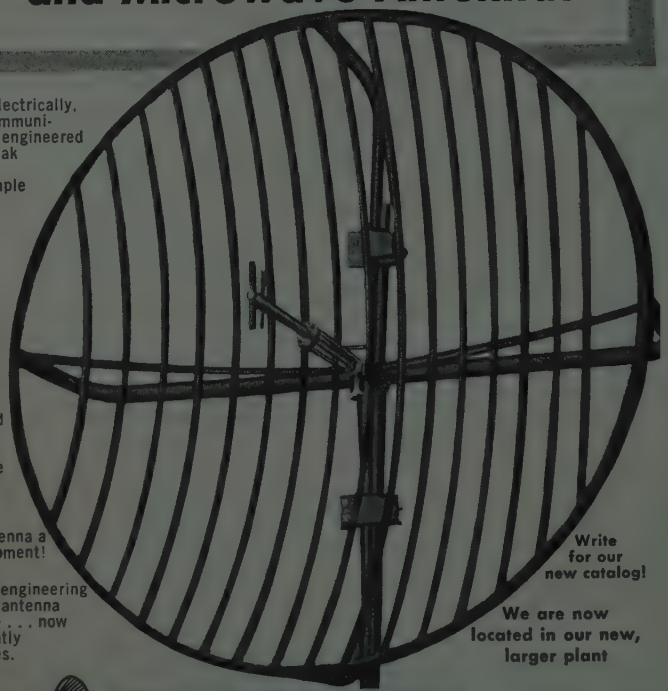
DATA PROCESS OUTPUT TRANSLATED INTO VISIBLE, PRECISE, RECORDS

- Records analog, digital and alpha numeric data

Write or phone for further information

TIMES FACSIMILE CORPORATION

Outstanding Design in UHF, VHF, 2-Way and Microwave Antennas



Both mechanically and electrically, Mark Antennas for all communications applications are engineered and manufactured for peak efficiency, maximum mechanical stability, simple installation and long trouble-free life.

PARABOLAS and Point to Point
For 450, 900, 2000 and 6000 MC. Up to 15' diameter. Rugged HELLIARC welded aluminum construction permits lighter, lower cost towers.

2 WAY COMMUNICATIONS
Mark High Gain patented Fiberglas Construction omnidirectional base station antennas provide gains up to 10 db.

RAILWAY and VEHICULAR
New low profile R R antenna a brand new Mark development!

SPECIAL DESIGN
Mark offers a complete engineering and research service in antenna design and manufacture . . . now supplemented with greatly increased plant facilities.

Write for our new catalog!

We are now located in our new, larger plant

MARK PRODUCTS

5439 Fargo Avenue ORchard 5-1500, Skokie, Illinois

(Continued from page 64A)

John L. Heins (A'32–VA'39) former Chief Electronics Engineer for the Republic Aviation Corp., Missile Systems Div., was named as head of engineering for the GB Electronics Div. of the General Bronze Corp.

J. L. Heins

He is an electronic systems specialist who has held engineering positions with I.T.T.L., Sperry, Burroughs and other organizations in the industry.

At GB Electronics Corp., he will take over the antenna systems organization and be responsible for an expansion program involving the application of proprietary corporation developments, such as the recently announced S.V.E. array now being applied for major contracts of the National Aeronautics and Space Administration, General Electric Co. and others involved in advanced type tracking and telemetry systems.

❖

Dr. Albert S. Hoagland (S'50–A'54–SM'57) has been appointed manager of Engineering Sciences Research at the San Jose, Calif., research laboratory of the International Business Machines Corp.

A. S. Hoagland

He joined IBM in June, 1956 as a project engineer working on the magnetic program for the RAMAC at the San Jose laboratory. A short time later his work was expanded to include magnetics work on the Stretch computer.

In January, 1958 he was appointed development engineer and continued responsibility as project leader for the magnetics program. In January of this year he was appointed senior research engineer and given responsibility for large-scale memory research.

Dr. Hoagland received the B.S., M.S., and Ph.D. degrees in electrical engineering at the University of California in Berkeley. He is a member of the AIEE, Phi Beta Kappa, Sigma Xi, Eta Kappa Nu, and Tau Beta Pi.

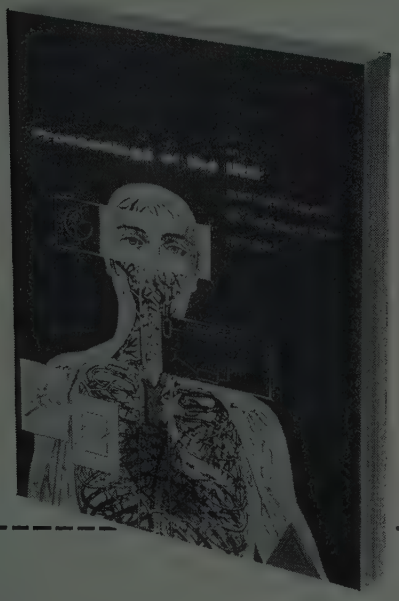
❖

John J. McDonald (A'50), director of engineering for Consolidated Systems Corp., wholly owned subsidiary of Consolidated Electrodynamics Corp., has been elected a vice president of the Instrument Society of America.

(Continued on page 68A)

Here is the fascinating field of

BIO-MEDICAL ELECTRONICS



The purpose of this special November issue of **Proceedings**, as outlined in the guest editorial by J. W. Moore, National Institute of Health, is "to provide its readers with some interesting, informative and perhaps provocative examples of various weddings of electronic art and concepts to some of the life sciences. This collection of articles is not intended to delineate Bio-Medical Electronics, but rather to illustrate the breadth of the field of interest of the Professional Group on Medical Electronics, which, by constitutional definition, is the study of biological and medical systems." Thus begins one of **Proceedings'** most fascinating issues—one that presents the scope of the broad new avenues of experimentation in biological measurements opened up by the speed, versatility and precision of modern electronics. This special issue is not only the current record of the progress in Bio-Medical Electronics, it is fascinating reading for radio-electronics engineers in general.

26 ARTICLES BY LEADERS IN THE BIO-MEDICAL ELECTRONIC FIELD

Below is just a partial listing of the articles this special issue covers. For example, the development of a broadband electrometer is described in the article by Gesteland, Howland, Lettvin and Pitts on "Microelectrodes and Their Use." This issue gives considerable emphasis to basic biological research. And, because the recruitment and training of personnel to work in the bio-medical instrumentation area is probably the most pressing problem to be faced by the PGME, there are supplementary articles in this area. This special November issue of **Proceedings of the IRE** on Bio-Medical Electronics is only one of the many services offered members of the IRE. If you are a non-member and wish a copy of this vital link in the record of radio-electronics, return the coupon below, today, to reserve it for yourself or your company.

PARTIAL CONTENTS OF THIS NOVEMBER BIO-MEDICAL ELECTRONICS ISSUE:

"An Analog Computer to Stimulate Systems of Coupled Bimolecular Reactions," by E. F. MacNichol, John Hopkins University

"Electron Transfer in Biological Systems," by B. Chance, University of Pennsylvania

"Alternating Current Spectroscopy of Biological Substances," by H. P. Schwan, University of Pennsylvania

"Comments on Microelectrodes," by R. C. Gesteland, B. Howland & J. Lettvin, Massachusetts Institute of Technology

"Some Functions of Nerve Cells in Terms of an Equivalent Network," by W. H. Freygang, National Institutes of Health

"Electronic Control of Some Active Bioelectric Membranes," by J. W. Moore, National Institutes of Health

"Measurement of Mechanical Properties of Muscle under Servo Control," by M. Lubin, Harvard University

"Scanning Microscopy in Medicine and Biology," by L. E. Flory, RCA Laboratories

"Instrumentation for Automatically Pre-Screening Cytological Smears," by R. C. Bostrom, H. S. Sawyer & W. E. Tolles, Airborne Instruments Laboratory

"A Magnetic Flowmeter for Recording Cardiac Output," by H. W. Shirer, R. B. Shackelford & K. E. Jochim, University of Kansas

"The Use of an Analog Computer for Analysis of Control Mechanisms in the Circulation," by H. R. Warner, Latterday Saints Hospital

"Some Engineering Aspects of Modern Cardiac Research," by D. Baker, R. M. Ellis, D. L. Franklin & R. F. Rushmer, University of Washington

"Stability, Oscillations, and Noise in the Human Pupil Servomechanisms," by L. Stark, Yale University

"What the Frog's Eye Tells the Frog's Brain," by J. Y. Lettvin, H. R. Maturana, W. S. McCullough & W. H. Pitts, Massachusetts Institute of Technology

"Repetitive Analog Computer for Analysis of Sums of Distribution Functions," by F. W. Noble, J. E. Hayes, Jr. & M. Eden, National Heart Institute

"Medical Ultrasonics," by J. F. Herrick, Mayo Clinic; H. P. Schwan & J. M. Reid, University of Pennsylvania

"The Use of Electronic Computers to Aid Medical Diagnosis," by R. S. Ledley & L. B. Lusted, National Academy of Sciences

"New Instrumentation Concepts for Manned Flight," by L. J. Fogel, Convair

"The Origin of the Professional Group on Medical Electronics," by L. H. Montgomery, Vanderbilt Medical School

"Instrumentation in Bio-Medical Research," by P. E. Klopsteg, National Academy of Sciences

"On the Role of the Engineer in Bio-Medical Instrumentation," by J. P. Hervey, Rockefeller Institute

"Medical Electronics Center—Interdisciplinary Coordination," by V. K. Zworykin, Rockefeller Institute

☐ Enclosed is $3.00

☐ Enclosed is company purchase order for the November, 1959, issue on Bio-Medical Electronics.

All IRE members will receive this November issue as usual. Extra copies to members, $1.25 each (only one to a member).

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3606

IRE People

(Continued from page 66A)

He will direct ISA activities in California, Hawaii, Arizona, Nevada, and part of Utah during his two-year term of office.

He has served the Society as a national director, director of the Transportation Industry Division, chairman of the Instrumentation for Transportation Committee, and chairman of the Research and Development Committee.

He is also a member of the American Institute of Electrical Engineers, Society for Experimental Stress Analysis, American Standards Association, and American Rocket Society. He was president of SESA's Chicago section in 1952, and at present is a member of the ASA's Committee to Establish Vibration Standards.

Mr. McDonald received the B.S. degree in physics from the University of Chicago and the B.S. degree in electrical engineering from the Armour Institute of Technology.

❖

Edwin R. Gamson (A'51–M'56), general manager of the Components Division of Telemeter Magnetics, Inc., Los Angeles, Calif., has been elected a vice president of the company. He was appointed to his present post as general manager in June of this year, when the components Division was organized. He joined TMI in 1956 as director of manufacturing, a position he held until his recent advancement.

E. R. GAMSON

Mr. Gamson was graduated from Stanford University in engineering sciences. He has been actively engaged in the development and manufacture of electronic components since 1948, with North American Aviation, Stanford Research Institute, and Telemeter Magnetics.

❖

Fred R. Wellner (A'51–M'52–SM'56) has been named manager of the Electrical Design Engineering Subsection of General Electric Co. He has been employed at General Electric for the past 9 years.

Born in Munich, Germany, he graduated from the German Naval College in 1940 with a degree in naval engineering. He was awarded the degree of Diplom-Engineer in electrical engineering by the Technical University of Munich in 1949 and he received the M.S. degree in electrical engineering from Syracuse University.

From 1949 to 1951 he was Chief Engineer for the Audivox Co., Boston, Mass. He joined General Electric's television receiver department at Syracuse in 1951 in the capacity of advanced development engineer. Five years later he was appointed supervisor of electrical design, the position he held at the time of his promotion to manager.

❖

(Continued on page 70A)

EARTHBOUND AND BEYOND

CANNON RF COAXIAL PLUGS MEET ANY CHALLENGE ANYWHERE

CANNON PLUGS

Cannon's complete line of RF coaxial plugs meet the exacting demands of today's technology with room to spare! Wherever coaxial cable is used; land, sea, air, or outer space, Cannon's RF plugs—standard, miniature, and light-weight aluminum—provide the exact type and size for any application . . . whether industrial or military • Aircraft • Missiles • Ground Support Equipment • Ships • Submarines • Write for literature to: CANNON ELECTRIC CO., 3208 Humboldt Street, Los Angeles 31, California • Please refer to Department 377

Largest Facility in the World for Plug Research—Development—Manufacture

DEEP THOUGHTS FROM DEEP DOMES / NO. 3 OF A SERIES

Scrubbs on Motherhood

Sir Joshua Wormwood-Scrubbs, FRMS, (1883-1949), developer of the celebrated automated fly trap, summed up a triumph over nature when he said: *"The normal mother fly has 320 children four times a year, and yet seems able to go out considerably between times."* Good show, say we at HOOVER ELECTRONICS!

We enjoy saluting triumphs, even when (immodestly!) they're of our own making. For example, we've commanded that there be whistle-blowing, bell-ringing, and ratchet-twirling for our new Millivolt Transistorized Oscillator, which has scored a resounding victory (and in the bottom of the ninth inning, too) over DC amplification in telemetering. The MTO, as we affectionately call it, makes it possible to feed the outputs of low-level transducers such as thermo-couples, strain gauges and accelerometers directly into the HOOVER Subcarrier Oscillator without DC amplification. A *neat trick!*

Another giant stride forward, this Millivolt Transistorized Oscillator eliminates a separate DC amplifier, which means fewer packages, lower power consumption, and the end of one possible source of error—one of telemetry's seven plagues. Ask us for details of this bell-ringing little triumph.

HOOVER

ELECTRONICS COMPANY

SUBSIDIARY OF THE HOOVER COMPANY

110 WEST TIMONIUM ROAD • TIMONIUM, MARYLAND

Field Liaison Engineers
Los Angeles, California

IRE People

(Continued from page 68A)

Robert E. Talmo (S'49–A'50–M'55) has joined the senior technical staff of Electro-Optical Systems, Inc., as head of the newly formed Transducer Laboratory of the company's Solid State Division.

In this position he will be responsible for development of solid state transducer devices and application of these to a wide range of instrumentation necessary for space exploration and advanced military weaponry.

Prior to joining EOS, he was Assistant Chief Engineer for Wiancko Engineering Company of Pasadena, Calif., where he had been since 1950. Before joining Wiancko, he was employed by Van Dusen Aircraft Company of Minneapolis, Minn., and prior to that was with Victoreen Instrument Company, Cleveland, Ohio.

Mr. Talmo is a member of the Instrument Society of America.

❖

Paul Pittman (S'51–M'57) has been appointed manager of the solid state electronics application section of the materials engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa. In his new position he will be in charge of the evaluation and application of semiconductor materials and devices.

P. F. PITTMAN

A graduate of Carnegie Institute of Technology, he has received the Bachelor of Science and Master of Science degrees in electrical engineering.

Mr. Pittman is a member of the American Institute of Electrical Engineers.

❖

George W. Sioles (M'52) has been named Section Head for audio research in the Acoustics and Magnetics Department of CBS Laboratories, Stamford, Conn. Before joining CBS Laboratories this year, he had been Engineering Manager for University Loudspeakers, Inc., with whom he had been associated since 1953. He conducted his own consulting and development service for specialized audio systems, and during the period 1950–1953, was Project Engineer for navigation and other training devices with the United States Naval Training Device Center.

G. W. SIOLES

Mr. Sioles received the B.S. degree from Columbia University following his service

(Continued on page 72A)

Distributed constant delay lines • Lumped-constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines • Shift registers •

ESC EXTRA

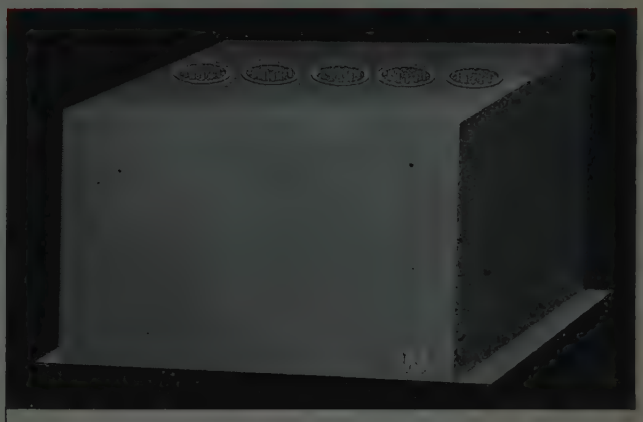
Pulse transformers • Medium and low-power transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies

ESC DEVELOPS DELAY LINE WITH 170 to 1 DELAY TIME/RISE TIME RATIO

Model 61-34 Perfected For Specialized Communications Application

PALISADES PARK, N. J.—An entirely new Lumped-Constant Delay Line, with a proven 170 to 1 delay time/rise time ratio, has been announced by the ESC Corporation, Palisades Park, N. J. The new delay line, known as Model 61-34, was specifically designed for a specialized communications application calling for the exceptionally high delay time/rise time ratio.

ESC, the world's leading manufacturer of custom built and stock delay lines, is already widely recognized in the electronics industry for its exceptional engineering advances. In October, 1958, ESC broke through an existing design barrier and produced a delay line with a 145 to 1 delay time/rise time ratio. It had been thought, prior to the announcement of the Model 61-34, that ESC had reached the ultimate in this type of delay line.



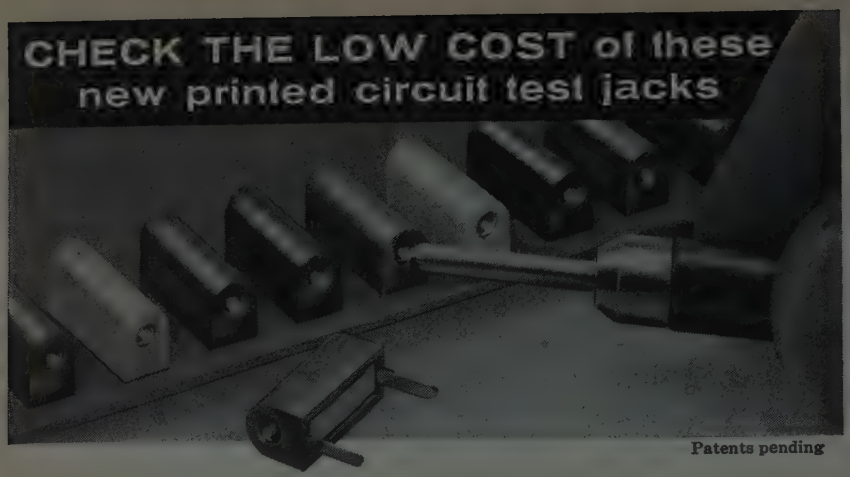
SPECIFICATIONS OF NEW DELAY LINE MODEL 61-34

Delay time/rise time ratio: 170/1
Delay: 200 usec.
Rise time: 1.16 usec.
Attenuation: less than 2 db
Frequency response: 3 db = 325 KC
50 taps with an accuracy of ±0.2 usec. at each tap.

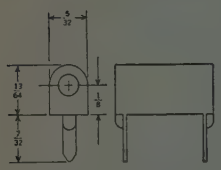
Complete technical data on the new unit can be obtained by writing to

ESC Corporation, 534 Bergen Boulevard, Palisades Park, New Jersey.

CHECK THE LOW COST of these new printed circuit test jacks



Patents pending



For .052 application holes on .400 centers

Samples on request

Ucinite's new test jack is designed for permanent, soldered assembly to printed circuit boards. Gold-over-silver-plated beryllium copper contacts provide low-resistance contact for repeated insertions of standard .080" diameter test probes. Nylon bodies are available in eleven standard code colors. Uniquely simplified construction affords economical usage in all quantities. Immediate shipments from stock.

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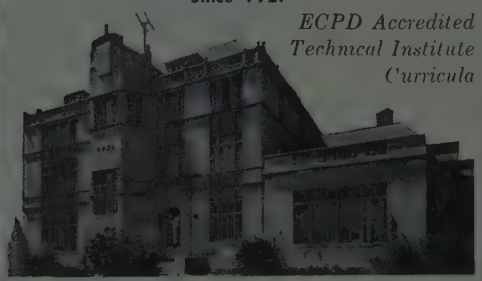

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rugged, versatile, high speed winder for bobbins, solenoids, resistors, relays and other random-wound coils.

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IRE People

(Continued from page 70A)

during World War II as B-29 bombardier-navigator. He is a member of the Acoustical Society of America and the Audio Engineering Society. He has published and presented papers on various aspects of loudspeaker design including the use of analog circuits. Patents are currently pending on collaborative work with colleagues on stereophonic projection loudspeakers.

❖

Alfred L. DiMattia (A'45) recently joined CBS Laboratories as Group Leader for research and development in electro-acoustic and electromechanical transducers. He has specialized in this field since 1942, when he entered the U. S. Government's wartime laboratory at Harvard University devoted to research in acoustics, psycho-acoustics, and communications. He subsequently held the position of Chief Engineer with the William J. Murdock Company, and he has served as acoustical consultant in the industrial and medical field. During the period 1947–1959, he was Design and Development Engineer in acoustics and electronics with the Dictaphone Corporation.

A. L. DiMattia

Mr. DiMattia is a member of the Acoustical Society of America, and the American Institute of Physics. His published papers in government publications and technical journals have dealt with primary calibration of microphones and acoustical measurements of other devices.

❖

Dr. Hans K. Ziegler (SM'56), an authority of satellite instrumentation and communications, has been named chief scientist at the U.S. Army Signal Research and Development Laboratory.

H. K. Ziegler

He had served as director of the Astro-Electronics Division since it was set up in January, 1959, to consolidate work on all national space projects assigned to the U. S. Army Signal Corps. Prior to this he had served as scientific consultant to the chief of the Power Sources Division and as assistant research director of the laboratory.

❖

Lynch Carrier Systems, Inc., San Francisco, Calif., have announced the appointment of **Henry G. Kuhn** (SM'54) to

(Continued on page 76A)

Microwave Component News from SYLVANIA

NOW IN PRODUCTION:

Widest Range of Backward-Wave Oscillators With Frequencies to 75 kmc

Actual length 10½"

	PM-1779	PM-1757	PM-6902	BW-623	6496	7096	6699
Frequency range, kmc	63-75	27-41	18-27	4-8	2-4	2-4	1-2
Power output, mw	3	5	10	15-135	20-700	100	20-700

Sylvania now offers the widest range of production backward-wave oscillators, featuring 3 rugged types at K-band and above.

Greatly simplified power supply design is made possible through use of the PM-1757 and PM-6902 since their design permits grounding of either cathode or helix. These two BWO's have the following advantages:

Grounded cathode
Rugged metal-ceramic construction
Permanent magnet focusing
Suitable for airborne applications
Rated for CW or pulse applications

For other requirements, Sylvania has classified tubes available at frequencies other than those shown.

SYLVANIA GENERAL SYSTEM

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Sylvania Electric Products Inc.,
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SILICON TRANSISTORS

JAN TRANSISTOR		Minimum Current Gain (B)	Maximum Collector Voltage (Volts)	Typical Cut-off Frequency (MC)	Maximum I_{co} @ 25°C and V_c Max. (μa)	FEATURES
	JAN-2N118	10	30	10	1	• Only Jan Silicon Transistor

SMALL SIGNAL		Minimum Current Gain (B)	Maximum Collector Voltage (Volts)	Typical Cut-off Frequency (MC)	Maximum I_{co} @ 25°C and V_c Max. (μa)	FEATURES
	2N333	18	45	7	50	• Low I_{co} • Operation to 175°C • 200 mw Power Dissipation
	2N335	37	45	10	50	
	2N480	40	45	11	.5	
	2N543	80	45	15	.5	
	ST905	36	30	10	10	

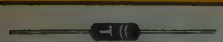
HIGH SPEED SWITCHING		Typical Cut-off Freq. (MC)	Maximum Collector Voltage (Volts)	Maximum Collection Saturation Resistance (ohms)	Max. Power Dissipation @ 100°C ambient (MW)	FEATURES
	2N1139	150	15	60	500	• High Frequency Operation • Low Saturation Resistance • Low I_{co}
	2N337	20	45	150	50	
	2N338	30	45	150	50	

MEDIUM POWER		Max. Power Dissipation @ 25°C Case (Watts)	Maximum Collector Voltage (Volts)	Minimum DC Current Gain (B)	Typical Rise Time (μsec)	Typical Fall Time (μsec)	FEATURES
	2N545	5	60	15	.3	.5	• Fast Switching • High V_c • Rugged Construction
	2N547	5	60	20			
	2N498	4	100	12			
	2N551	5	60	20			
	2N1140	3	40	20	.2	.1	

HIGH POWER		Maximum Power Dissipation ... 25°C Case (Watts)	Minimum DC Current Gain (B)	Typical Collector Saturation Resistance (Ohms)	Maximum Collector Voltage (Volts)	FEATURES
	ST400	85	15 @ 2 Amps	1.5	60	• High Current Handling Ability • Low Saturation Resistance • Rugged Construction
	2N389	85	12 @ 1 Amp	3.5	60	
	2N424	85	12 @ 1 Amp	6.0	80	

Write for Bulletins TE-1351 and TE-1350

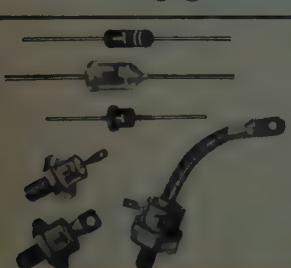
SILICON DIODES



FEATURES	Fast Switching and High Frequency Types Ratings @ 25°C				Military and High Conductance Types Ratings @ 150°C			
		Max. Inverse Voltage (Volts)	Max. Average Fwd. Current, (ma)	Inverse Recovery Time (μsec)		Max. Inverse Voltage (Volts)	Max. Average Fwd. Current (ma)	Max. Inverse Current (μa) @ V
• Recovery Times Under 15 μsec • High Conductance Combined With Fast Switching • Subminiature Size • High Inverse Resistance	1N808	100	100	.3	JAN 1N457	60	25	5 @ 60
	1N809	200	100	.3	JAN 1N458	125	25	5 @ 125
	1N658	120	200	.3	JAN 1N459	175	25	5 @ 175
	1N659	55	100	.3	1N485B	180	50	5 @ 175
	1N643	110	100	.3	1N488A	380	50	25 @ 380
	JAN 1N251	30	75	.15	1N464	175	40	30 @ 125

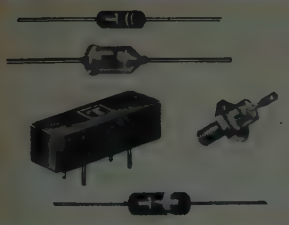
SILICON RECTIFIERS

Write for Bulletin TE-1350

Ratings @ 150°C Case Temperature			Peak Recurrent Inverse Voltage (Volts)	Maximum Average Forward Current (ma)	Maximum Inverse Current (ma)	FEATURES
	Subminiature Glass	1N689 1N649	600 600	150 150	0.2 0.2 (@ 25°C)	• Reliability at High Temperatures • High Efficiency • Rugged Construction • Hermetic Sealing • Low Thermal Resistance
	Miniature	T162A T130A	600 300	200 200	0.5 0.5	
	Axial Leads	SL715 1N547	1500 600	100 250	0.2 0.3	
	Military	JAN 1N256	570	200	0.25 (@ 135°C)	
	Stud Mounted	TM155 TM67	1500 600	400 3000	0.5 0.5	
	Medium Power	TR402 TR601	400 600	Amps 20 10	5 5	
	High Power	TH402B	400	50	15	

Write for Bulletin TE-1351

SILICON REGULATORS AND REFERENCES



	Voltage Range (Volts)	Maximum Dynamic Resistance (ohms)	Maximum Current @ 25°C (ma)	@ 125°C (ma)	FEATURES
Subminiature — SV-5	4.3-5.4	55	50	10	• Long-term stability • Operation up to 150°C • Small size, easy mounting • Hermetically sealed
Miniature — SV-815	13.5-18	120	40	8	
Power — SV-924	20-27	8	55°C (amps)* .4	(ma)* 100	
Stabistor — SG-22	.64	40	150	25	
Reference — SV-3176	8-8.8	15	Temp. Coefficient ±.001%/°C		
Ref-Amp — 3N44	8.3-9.8		±.002%/°C		

*Case temperature ratings

Write for Bulletin TE-1352

SILICON CAPACITORS

Ultra High Frequency Types — Ratings @ 25°C							FEATURES
	Cut-off Freq. (mc)	Capacity (μμf) @ V Max.	@ −0.1V	Q @ −4V @ 50Mc	@ 100Mc	Maximum Working Voltage	
SCH-51	5000	.35	2	100	50	10	• Subminiature Size • High Q • High Temperature Operation
SCH-52	5000	.8	4	100	50	7	

High Frequency Types						
				Q @ −4V At 5mc	At 50mc	
SC-1		4.4	24	350	35	22
SC-5		25	120	350	35	11
SC-15		120	360	350	35	6

GERMANIUM DIODES

Write for Bulletin PB-45

FEATURES

- Milli Microsecond Switching
- Superior Forward Conductance
- High Inverse Resistance
- Uniformity and Stability
- Gold Bonded Construction

Specifications and Ratings at 25°C	Forward Current @ +1V (ma)	Inverse Current at Specified Voltage (μa @ V)	Max. Oper. Voltage (volts)	Description
JAN-1N270	200	100 @ −50	80	JAN TYPES
JAN-1N277	100	250 @ −50 @ 75°C 75 @ −10	100	
JAN-1N281	40	500 @ −50 30 @ −50	60	
JAN-1N126	5	500 @ −50 30 @ −10	60	
JAN-1N198	5	250 @ −50 @ 75°C 75 @ −10	50	
1N283	200	20 @ −10	20	COMPUTER TYPES
T16G	40	100 @ −50	60	
1N278	20	125 @ −50 @ 75°C	50	HI-TEMPERATURE TYPES
T22G	40	20 @ −10 @ 75°C	15	
T9G	100	20 @ −50 2 @ −10	60	HI-RESISTANCE TYPES
1N67A	5	50 @ −50 5 @ −5	80	
T8G	100	20 @ −100 5 @ −10	100	
S570G	10	30 @ 6	Recovery Time .002 (μsec)	MILLI-MICROSECOND SWITCHING

GERMANIUM COMPUTER TRANSISTORS

Write for Bulletin TE-1309 & TE-1310

	Minimum Current Gain (β)	Maximum Collector Voltage (volts)	Typical Cutoff Freq. (MC)	FEATURES
2N427	40	15	8	• High Frequency Switching • Low Saturation Resistance • Uniform Input Characteristics
2N428	60	12	13	

Your local authorized TRANSITRON DISTRIBUTOR now carries in-stock inventories for immediate delivery.

Transitron's TD series of rectifier stacks offer a wide range of ratings in seven standard circuit configurations. High voltage cartridges, quads, plug-in assemblies, and many other special encapsulations are also available. Your inquiries are invited.
Write for Bulletin TE-1342.

Transitron

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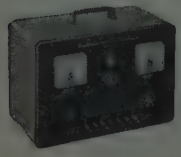
ELECTRONIC KITS

The Heathkit Model OP-1 Professional 5" DC Oscilloscope is an example of the top quality test instruments available from Heath at ½ the price you would expect to pay. This feature-packed kit sells complete for only $179.95.

Heathkits give you twice as much equipment for every dollar invested.

The Heathkit Model V-7A is the world's largest selling VTVM. Precision 1% resistors are used in the voltage divider circuit for high accuracy and an etched circuit board simplifies assembly and cuts construction time in half. Price of this outstanding kit is only $25.95.



The Heathkit Model PS-4 Variable Voltage Regulated Power Supply Kit is another outstanding example of Heath Company engineering ingenuity. Truly professional in performance as well as appearance yet it costs only $54.95.

Stretch your test equipment budget by using HEATHKIT instruments in your laboratory or on your production line. Get high quality equipment without paying the usual premium price by letting engineers or technicians assemble Heathkits between rush periods. Comprehensive step-by-step instructions insure minimum construction time. You'll get more equipment for the same investment and be able to fill any requirement by choosing from more than 100 different electronic kits by Heath. These are the most popular "do-it-yourself" kits in the world, so why not investigate their possibilities in your business. Send today for the free Heathkit catalog!

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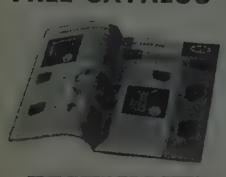

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IRE People

(Continued from page 72A)

the position of Chief Engineer.

H. G. KUHN

He has had more than 20 years experience in communications with particular emphasis upon carrier telephone and telegraph circuitry and equipment. His most recent employment was with Lenkurt Electric Co., San Carlos, Calif., as Executive Staff Engineer specializing in carrier telephone, remote control and communication switching systems.

He was formerly a Laboratory Head for the Philips Company in Germany and completed five years with this same company at their Canadian branch. Other employment includes seven years with Siemens & Halske in Germany as a design and development engineer.

Mr. Kuhn graduated from Technical College, Mittweida, Germany, with the Electrical Engineering degree and subsequently did graduate work at Technical University, Dresden, Germany. He holds seven U. S. Patents and European patents in communications and electronics.

❖

At its eighth annual meeting in Boston on September 22, 1959, the Standards Engineers Society conferred its Fellow grade of membership on **Harold P. Westman** (J'24–A'25–M'30–SM'43), manager of technical publications, International Telephone and Telegraph Corporation, for his work on standardization over the past thirty years.

After a dozen years of close association with the standards program of the IRE as its national secretary, he served on the staff of the American Standards Association during the war to develop a series of American War Standards on radio and electronic components for the armed services. He has since served on numerous ASA committees concerned with such editorial subjects as abbreviations, illustrations for publication, graphical and letter symbols, and definitions of engineering terms.

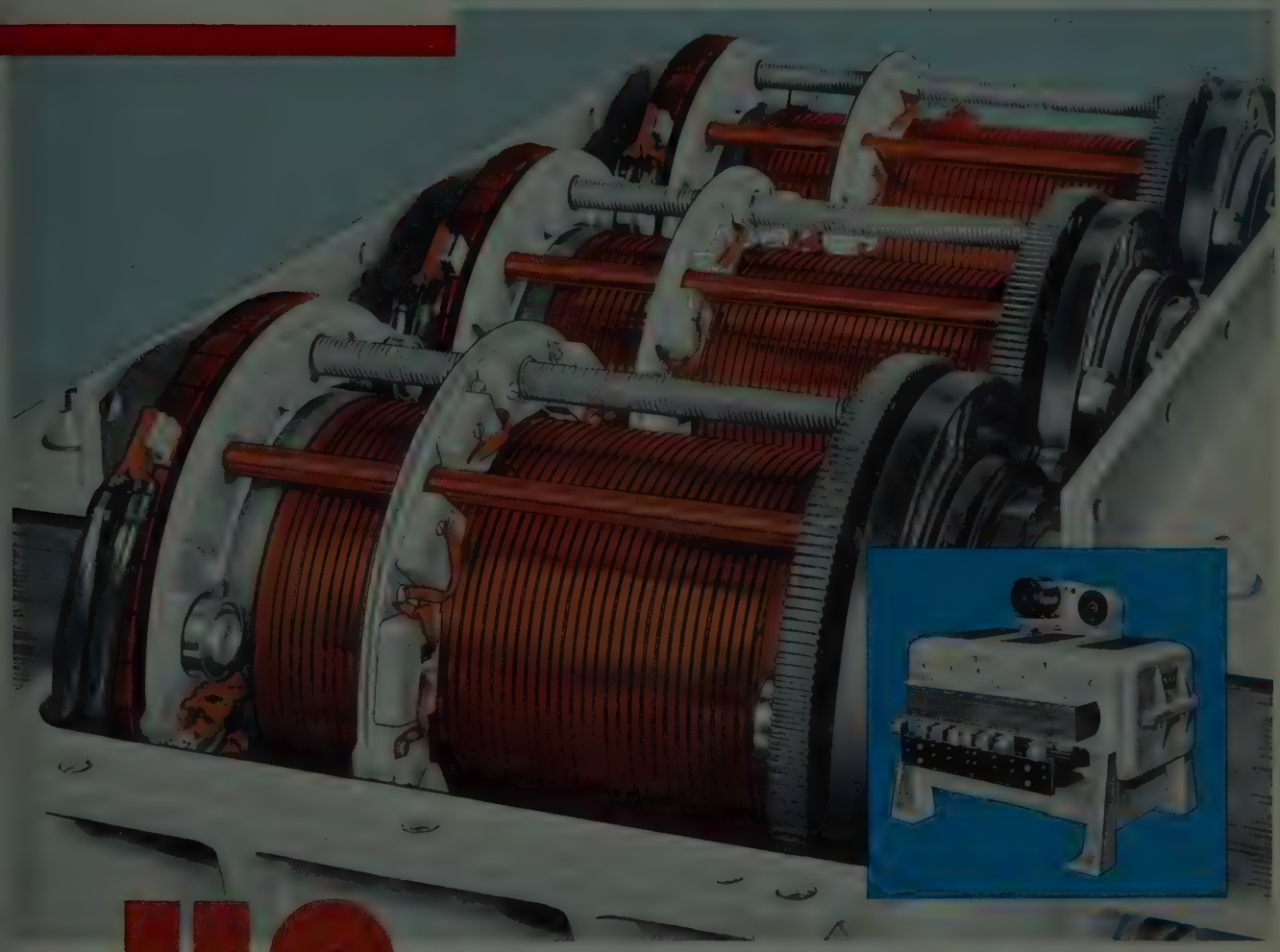
Mr. Westman is editor of the engineering quarterly, Electrical Communication, and of the present edition of Reference Data for Radio Engineers, both of which are published by ITT.

❖

Joseph W. Stehn (M'55) has been appointed Director of Military Sales of the W. L. Maxson Corporation. In his new post, he will be responsible for directing all sales activities of Maxson's Defense Products Group, which specializes in the

(Continued from page 80A)

A COMPLETELY NEW CONCEPT *in variable transformer design!**



the **HC** *series* **POWERSTAT®** *variable transformers*

HIGH CURRENT CAPACITY
— The use of a helical wound coil design instead of the conventional toroidal wound coils permits current capacities much higher than previously available in variable transformers.

EXTREMELY FINE ADJUSTMENT
— Patented re-entry rings permit continuously-adjustable control of 1600 increments over the range of zero to maximum output voltage. Resolution is better than 1/10 of 1% of the input voltage.

HIGHEST EFFICIENCY
— Low resistance brushes are always in contact with only one turn of the helical wound coil resulting in very low voltage drop.

PLUS:

ZERO WAVEFORM DISTORTION, EXCELLENT REGULATION, SMOOTH CONTROL, CONSERVATIVE RATINGS, LINEAR OUTPUT VOLTAGE, LOW COST PER KVA.

THE
SUPERIOR ELECTRIC
COMPANY

Bristol, Connecticut, U.S.A.

* The Superior Electric Company's U.S. Patent No. 2,864,992

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NEVER BEFORE

• *such high efficiency* • *such fine adjustment* • *such high current capacity*

the H-C series POWERSTAT® variable transformers

for heavy duty applications requiring cool, efficient operation

TYPES

Two 240 volt, 3-phase types are offered. Type 2HC200-3Y is cooled by normal convection. Type 2HCB200-3Y is similar in construction but incorporates fans for forced air cooling of the coils. Output rating of the forced air cooled type is nearly double that of the convection cooled type. Types for 480 volt, 3-phase duty are available also.

POWERSTATS *of the H-C Series can be remotely operated from a control unit mounted either on the POWERSTAT frame or at any other convenient location. Raise-lower signals from the control unit operate the adjustable speed motor driving the contact brush assembly. Full range travel speed is fully adjustable between 15 seconds and 10 minutes. Travel is smooth with fast starting and stopping at any voltage setting. Integrally mounted travel limit switches provide stops and unit protection.*

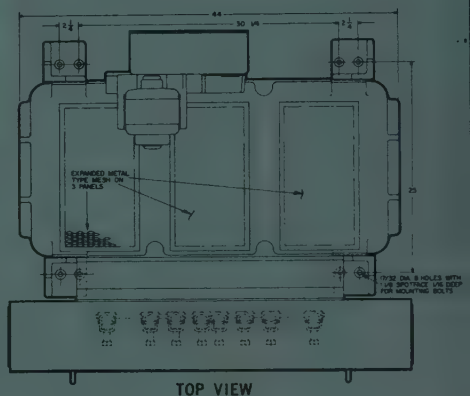
TYPE 2HCB200-3Y (FORCED AIR COOLED)

INPUT:	240 VOLTS	60 CYCLES	3 PHASE
OUTPUT:	0-270 VOLTS	360 AMPERES	168 KVA

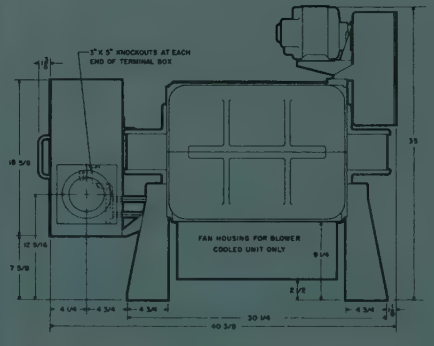
TYPE 2HC200-3Y (CONVECTION COOLED)

INPUT:	240 VOLTS	60 CYCLES	3 PHASE
OUTPUT:	0-270 VOLTS	200 AMPERES	93.5 KVA

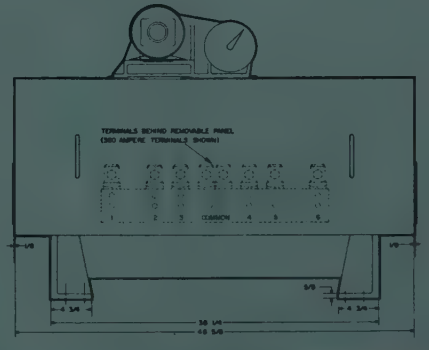
OUTLINE DIMENSIONS



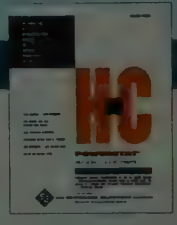
TOP VIEW



SIDE VIEW



FRONT VIEW



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THE SUPERIOR ELECTRIC COMPANY, Bristol, Connecticut

☐ Please send H-C Series POWERSTAT Bulletin.

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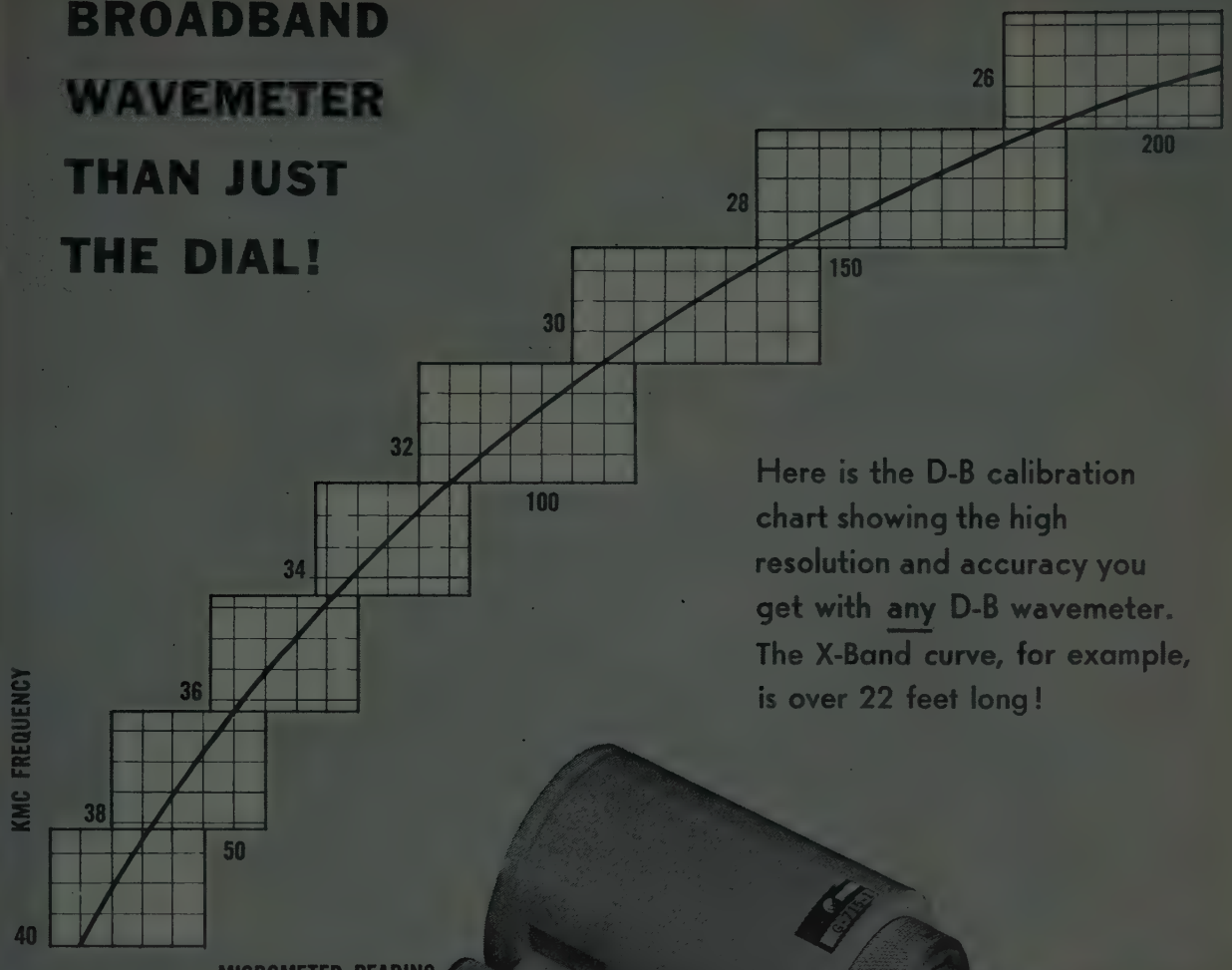
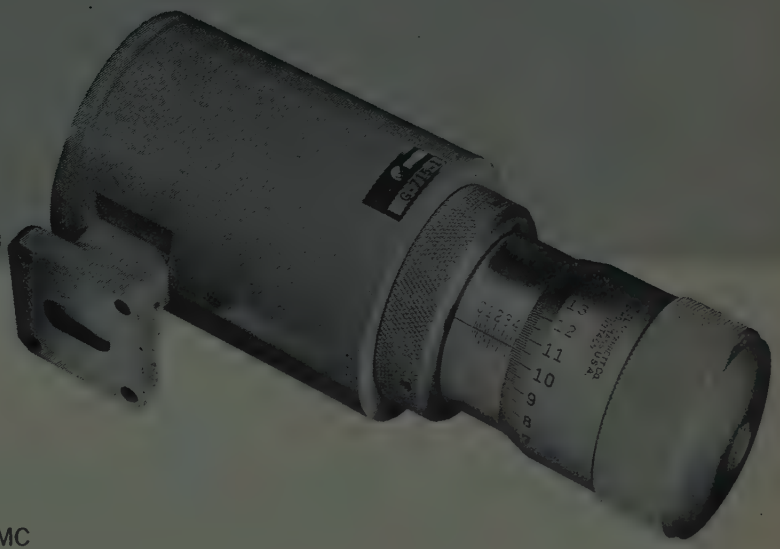
Bristol, Connecticut, U.S.A.

THERE'S MORE TO A D-B BROADBAND WAVEMETER THAN JUST THE DIAL!



Here is the D-B calibration chart showing the high resolution and accuracy you get with any D-B wavemeter. The X-Band curve, for example, is over 22 feet long!



Fail-Safe Design— loss of gas pressure makes unit immediately inoperative.

Twelve models cover from 2.6 KMC to 140 KMC. Write for complete data in Bulletin D-B 715.

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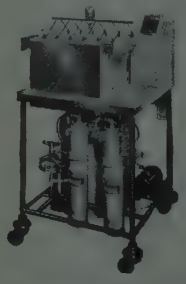
WATER PURIFICATION EQUIPMENT

18,000,000 *ohm* WATER

This Barnstead equipment in series consists of sand and carbon filter, high-capacity 4-bed demineralizer, 2 Barnstead® high-purity Stills, tin-lined tank, mixed-bed demineralizer, MF® Submicron filter, tin-lined heater. RESULT: 18,000,000 ohm water in production quantities . . . free from organics, bacteria, and submicroscopic particles down to 0.45 micron.



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Rinses transistors, diodes, and other small components in hot, ultra pure water. Filters out particles to 0.45 micron. Continuous repurification system conserves water, results in substantial savings. Write for Bulletin 146.

COOLING WATER RE-PURIFYING SYSTEM adds thousands of hours to UHF transmitting tube life. Maintains cooling water at high purity level. Write for Bulletin 149.

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IRE People

(Continued from page 76A)

research, development and production of advanced airborne, missile and ordnance components and systems.

Since joining Maxson in 1953, he has served successively as Contracts Administrator, Applications Engineer, Manager of Ordnance Products, Manager of Electronic Products, and most recently as Assistant Sales Manager.

Following World War II, in which he served as a Captain in the U. S. Army, he attended Manhattan College from which he was graduated in 1949 with the B.S. degree in electrical engineering.

Mr. Stehn is a member of the American Ordnance Association.

❖

Dr. Arthur G. Anderson (A,54) has been appointed manager of the Physical Science research at the San Jose, Calif., research laboratory of the International Business Machines Corporation.

A. G. ANDERSON

He joined IBM in May 1951 as a technical engineer working on analytical mechanics, acoustics and instrumentation on mechanics problems at the Poughkeepsie, N. Y., research laboratory.

He was subsequently appointed to the positions of associate engineer, staff engineer, and research engineer, and has worked in high speed computer research, spin echo storage, research in solid state physics, nuclear magnetic resonance in solids, and has served as acting manager of the physics and chemistry research group at the San Jose laboratory.

Dr. Anderson received the B.S. degree in physics at the University of San Francisco, the M.S. in mathematics at Northwestern University, and the Ph.D. in physics at New York University. He is a member of the American Physical Society and the Scientific Research Society of America.

A native of Glenview, Illinois, Dr. Anderson is married and has two sons and a daughter. The family make their home in Morgan Hill, California.

❖

William Perzley (A'54) is the new director of engineering at Consolidated Avionics Corp., Westbury, N. Y. The firm, a manufacturer of electronic data reduction systems, instrumentation, automatic test and control systems and transistorized power supplies, is a subsidiary of Consolidated Diesel Electric Corp.

Prior to joining Consolidated Avionics, he was chief electronics engineer for Kaiser Metal Products Corp. and an engineering supervisor for American Bosch Arma. His work has included the development of such items as large scale general purpose digital machines, numerical control systems for machine tool control, lightweight airborne computers and associated test equipment.

A graduate of Newark College of Engineering, Mr. Perzley holds a master s degree in electrical engineering from Stevens Institute of Technology. He has also done graduate work at the University of Pennsylvania and M.I.T. He holds several basic patents in the digital instrumentation field.

❖

An advanced nuclear system company, the Atomium Corporation, has been announced by **Hugh F. Stoddart** (M'55), president of the new Waltham, Mass. plant. The firm designs and manufactures special nuclear systems of high engineering and physics content. The three primary areas of activity are controlled background low-level radiation detection facilities, automatic nuclear systems, and special medical nuclear instrumentation.

Mr. Stoddart was formerly vice president in charge of atomic instruments at Baird-Atomic, Inc. **James B. Williams** (S'53–M'56) is vice president of the corporation; he was formerly chief physicist and later marketing manager for Baird-Atomic.

Leonard W. Cronkhite, chairman and treasurer of Atomium Corporation was recently a director and vice president of Baird-Atomic.

❖

Radiation, Inc., Melbourne, Fla., has announced the appointment of **Louis P. Clark** (SM'56) as Manager of the Florida Division. He is also a Vice President of the company.

L. P. CLARK

A founder and former executive vice president of Tele-Dynamics Inc., Philadelphia, Pa., he brings to his new post over 25 years of executive experience in the advanced electronics industry. This long and outstanding service has earned Mr. Clark a national reputation for leadership in the fields of telemetry, communications, and instrumentation. He is National Vice Chairman of the PGTRC, a member of the American Rocket Society, the Armed Forces Communications and Electronics Association and the American Ordnance Society.

❖

J. A. Tucker (M'56), Assistant to the Department Head, Electrical Engineering Department, M.I.T., has been elected to the National Board of Directors of the Eta Kappa Nu Association, Electrical Engineering Honorary Society. He served as President of the Boston Alumni Chapter of this Association during 1953–54 and has been on its Advisory Board since.

Mr. Tucker is currently Assistant to Dr. Jerome B. Wiesner, Acting Head of the Department of Electrical Engineering at M.I.T.

❖

AMPEX PRECISION NOW 'LOCKED IN'

Lose the precise alignment of tape guiding and driving components in an instrumentation recorder and you lose the fine edge of designed-in performance. As alignment is lost, flutter and skew set in.

In the new Ampex FR-100B analog recorder, the possibility of misalignment—even under conditions of shock and vibration incidental to shipment or installation — is now eliminated by a framework of three precision castings with machined 'V' mating surfaces that lock all critical parts into a single rigid unit. The result: an instrumentation recorder with built-in performance and reliability that stays built in.

Other advanced features: 1. A unique electrical hold-back system keeps tape tension constant within narrow limits, reducing flutter and eliminating mechanical feedback of speed variations. 2. Modular plug-in amplifiers and power supplies give quick versatility for direct, FM carrier, PDM, and NRZ digital recording. 3. Front-panel, four-speed switching over a six-speed range from 1⅞ to 60 ips allows flexibility in selecting upper frequency limit for maximum tape economy.

These and other features of the new Ampex FR-100B add up to unmatched performance and reliability. The full story is available in the new Ampex FR-100 brochure.

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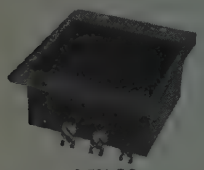
AMPEX
CORPORATION

For HEAVY DUTY WORK!
Severest Electrical Services

JONES
PLUGS & SOCKETS
500 SERIES
Proven Quality!

P-506-CE—Plug with Cap


S-506-DB
Socket with deep Bracket

For 5,000 Volts, 25 Amperes per Contact Alterable by Circuit Characteristics

Socket contacts or phosphor bronze, knife-switch type, cadmium plated. Plug contacts hard brass, cadmium plated. Made in 2, 4, 6, 8, 10, and 12 contacts. Plugs and sockets polarized. Long leakage path from terminal, and terminal to ground. Caps and brackets, steel parkerized (rust-proofed). Plug and socket blocks interchangeable in caps and brackets. Terminal connections most accessible. Cap insulated with canvas bakelite.

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NEW
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ARE
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(actual size, 1½ microsecond delay line)

Now you can achieve continuous delay variations electrically. Particularly suited to defense applications, these General Electric Delay Lines provide total delays up to 12 microseconds (depending on frequency) and a variability range up to 50%. With special delay lines for carrier or pulse type applications at frequencies to 30 megacycles, the electrical variation of delay provides a new method for solution of problems in:

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Section Meetings

AKRON

"The Bell System and Continental Defense," Dale Moon, Ohio Bell Telephone Co. 9/16/59.

ALAMOGORDO-HOLLOMAN

"Hi-Fi and Stereo," Dr. M. Jones, Geo. Science: Demonstration of Hi-Fi and Stereo by Maj. Ursel Nolte, USAF. 9/21/59.

ATLANTA

Guided tour of Lockheed Aircraft Corp. 9/25/59.

BALTIMORE

"The Air Defense of North America," Col. C. E. Towne, North American Air Defense Command. 9/14/59.

BENELUX

"General Principles Affecting Shipboard Radio Communications," C. B. Broersma, Radio-Holland N.V.; "The Radio Station Aboard the S. S. Rotterdam," H. T. Hylkema, Radio-Holland N. V.; "Electronic Navigational Aids on the S. S. Rotterdam." A. Wepster, Holland-American Lines. Visit to the S. S. Rotterdam. 10/3/59.

BINGHAMTON

"Flight Simulators," William Wood, Link Aviation, Inc.; "Fringe Count Micrometer," J. Whitmore, Link Aviation, Inc. Plant tour of Link Aviation. 10/14/59.

CENTRAL FLORIDA

"IRE of Yesterday," Arthur Van Dyke, Past President IRE. 4/25/59.

"Radar Reflectivity Measurements," M. Cox, Radiation, Inc. 6/18/59.

"Project Mercury—Man in Outer Space," G. Lowe, NASA. 9/17/59.

CENTRAL PENNSYLVANIA

"Stacked-Mount Vacuum Tubes with a Choice of Glass or Ceramic Envelopes," C. F. Douglass, Sylvania Electric, Inc. 9/15/59.

CINCINNATI

"Manned Versus Unmanned Space Observation," Col. J. P. Stapp, USAF. "The Emotional Dynamics of Sports," P. Harmon, Cincinnati Post and Times Star. "Sports and your Child," R. Schwartz, Boxing and Sports Analyst. 9/15/59.

CLEVELAND

"Design of Control Systems for Space Vehicles," P. E. Lannan, Designers for Industry. 9/10/59.

"Antarctica," Rev. H. F. Birkenhauer, S. J., John Carrol University. 10/8/59.

DALLAS

"Do Tubes Leak?" Dr. H. D. Doolittle, Machlett Laboratories. 9/15/59.

DENVER

"The Space Age and IRE," Dr. Ernst Weber, President IRE. 9/22/59.

DETROIT

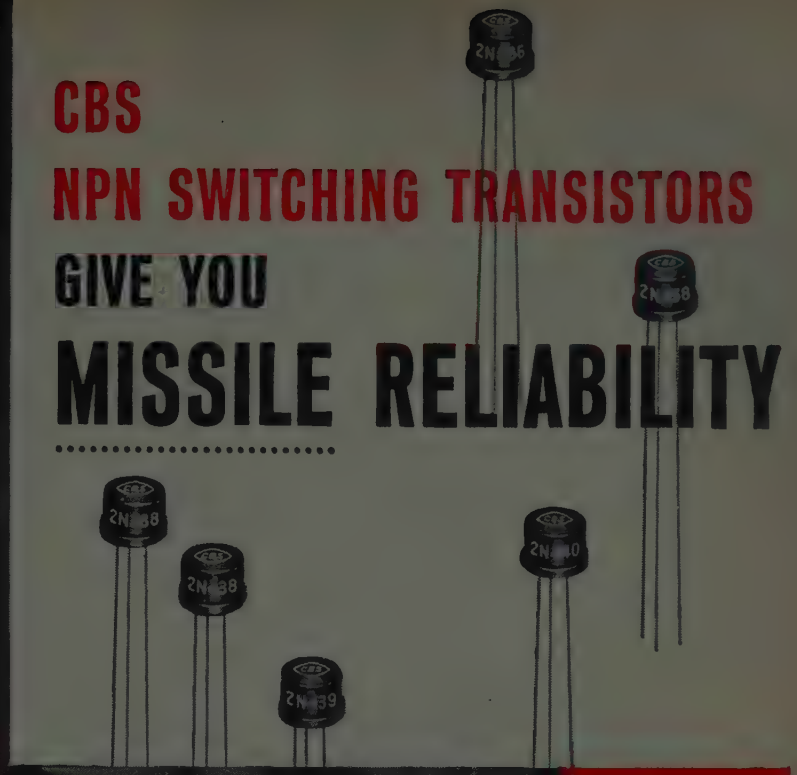
"Global Communications by Means of Satellites," Dr. J. B. Wiesner, MIT. 9/18/59.

ELMIRA-CORNING

"Technological and Sociological Factors Influencing the Military Utility of Space Vehicles," Israel Katz, General Electric Co. 9/28/59.

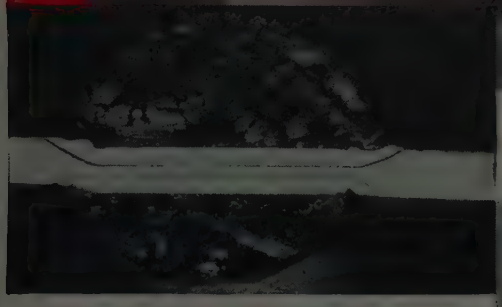
(Continued on page 84A)

CBS NPN SWITCHING TRANSISTORS GIVE YOU MISSILE RELIABILITY



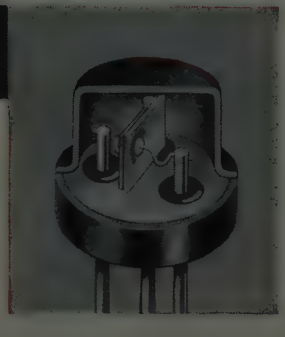
Here Are Some of the Reasons Why . . .

Contamination is eliminated. Baking, surface treatment, electrical testing and package welding are all conducted in dry-boxes at a dewpoint temperature below —90°F.



Flat, even junctions avoid "hotspots." Precise control of time and temperature (±0.03%) of alloying process eliminates localized heating, gives long reliable life. Characteristics are more uniform.

Ruggedness exceeds MIL specification. Severe requirements for shock (1000 g, 1 ms), vibration (10 g, 100-3000 cps) and acceleration (20,000 g) are met by: electronic welding of formed lead wires, horizontal base tab, and welded JEDEC TO-9 case.



CBS NPN switching transistors have proved themselves in flight in many of our important "birds." They have been found to have the advantages of fast switching, high voltage, low cutoff current, and low saturation resistance. All 28 of these CBS transistors exceed the MIL-T-19500A specification.

This same proven reliability under the most adverse environmental conditions is yours for military or industrial core drivers, logic circuits or general switching functions. Write for complete data sheet E-353. Order from your local Manufacturers Warehousing Distributor.

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2N312	2N358	2N438	2N440	2N446	2N634	2N1012
2N356	2N377	2N438A	2N440A	2N447	2N635	2N1090
2N356A	2N385	2N439	2N444	2N556	2N636	2N1091

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Section Meetings

(Continued from page 82A)

EL PASO

"Subsonic Amplifiers and Microphones," Prof. T. Barnes, Texas Western College. 9/24/59.

FLORIDA WEST COAST

"Radio Aids to Positioning and Navigation," Col. E. L. White, Retired. 9/16/59.

FORT HUACHUCA

"Hi-Fi and Stereo Sound," A. Woolery, Cactus Radio Network. 9/28/59.

HAWAII

"Automatic Switching Center as Developed by Western Union," K. M. Leber, Western Union Telegraph Co. 8/12/59.

"Problems in Reception of Signals from Space Satellite Vehicles," E. Farger, Jr., University of Hawaii. 9/9/59.

HUNTSVILLE

"Evolution of Radio Astronomy," J. M. Donnini, Brown Engineering Company; "Equipment and Hardware," E. Wells, ABMA; "The Radio Sky," R. D. Ferdie, Chrysler Missile Division. 7/30/59.

"High Reliability Statistically Demonstrated (Capacitors)," B. L. Wheeler, Vitramon, Inc. 10/8/59.

KANSAS CITY

"Transistor Manufacturing Techniques," R. Berger, Western Electric Co., Inc. 9/8/59.

"Project Mercury," R. J. Pierce, Collins Radio Co. 10/13/59.

LITTLE ROCK

"The Electronic Production of Choral Tone," W. C. Wayne, Jr., Baldwin Piano Co. 10/12/59

LONDON

Tour of Dominion Electrohome, Inc., with explanations by Frank Gordon. 9/22/59.

"Education for the Electronic Age," Dr. Ernst Weber, President IRE. 10/9/59.

LONG ISLAND

"Stero Transmission by FM Broadcasting," M. G. Crosby, Crosby-Teletronics Corp. Movie: "The Significant Years." 9/8/59.

LOS ANGELES

"The U. S. Army Electronic Proving Ground, Fort Huachuca, Arizona," Col. E. T. Bullock, USA; "Automatic Data Processing," Capt. J. Crawford, USA. 9/1/59.

"Frontiers at Infinity—World's Largest Radio Telescope," Prof. A. B. C. Lovell, University of Manchester, England. 10/1/59.

LUBBOCK

Film "Sage," Comments by L. Pease, Southwestern Bell Telephone Co. 9/22/59.

MIAMI

"University Meterology Radar Station," P. R. Ray and H. W. Kiser. 9/24/59.

MONTREAL

"Electron Beam Parametric Amplifiers," Dr. F. J. F. Osborne, Canadian Marconi Co. 9/23/59.

NORTH CAROLINA

"Semiconductor Switching Equipment for Broad Band Video," J. W. Wentworth, RCA. 9/18/59.

(Continued on page 86A)

interfering

electromagnetic energy

within the frequency range of

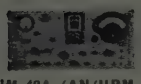
30 cps to 10.7 kmc

...can be investigated, analyzed, monitored and measured to the highest practical degree of accuracy with Stoddart Radio Interference & Field Intensity Measuring Systems.

Stoddart RFI Measuring Equipment is approved for use by all departments of the Department of Defense. Military and commercial equipments are identical... were designed and manufactured to Military Equipment Specifications to meet the requirements of Military Measurement Specifications. Equipments are portable, dripproof, dustproof, and ruggedized for all-weather field use... precise and dependable for sensitive-selective laboratory measurements.

Applications include interference measurement and location, frequency conservation and allocation studies, spectrum signatures, antenna propagation studies, field intensity surveys, RF energy surveillance and monitoring, and verification of the electronic compatibility of modern weapons systems, i.e., missile firing and guidance, computer, telemetering and communications; the measurement of all rotating electrical devices, transmitting and receiving equipment, or any system or equipment capable of producing unwanted radiated or conducted electrical disturbances.

Stoddart instruments are available as individual self-contained units covering specific frequency ranges, or in rack-mounted console systems for laboratory, mobile, airborne and marine use.



NM-40A (AN/URM-4I)
30 cps to 15 kc

NM-10A (AN/URM-6B)
14 kc to 250 kc

NM-20B (AN/PRM-1A)
150 kc to 25 mc

NM-30A (AN/URM-47)
20 mc to 400 mc

NM-50A
(AN/URM-17)
375 mc to 1000 mc

NM-60A
(AN/URM-42)
1 Kmc to 10.7 Kmc

our sales engineering department

will give you individual consideration and information in the areas of interference problems or measurement with which you are particularly concerned... provide engineering bulletins, military specification information, descriptions of new measurement techniques and applications... class or individual instruction in the operation, calibration, and maintenance of Stoddart instruments. For prompt service please call "Sales Engineering", HOllywood 4-9292.

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Immediate delivery

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serving 33 countries in radio interference control

Designed for

Application

BINDING POSTS AND PLUGS

Miniature binding posts, plates and plugs are available in addition to the regular line of standard size units. The plates, plugs, and insulated binding posts are available in black or red. The plugs and plates are also available in low loss mica filled phenolic.

JAMES MILLEN MFG. CO., INC.

MALDEN

MASSACHUSETTS

Section Meetings

(Continued from page 84A)

NORTHERN NEW JERSEY

Panel discussion on "Educational Television," E. deA. Partridge, Montclair State College; "Chelsea Closed Circuit Television Project," L. Creshkoff and Leon Polk, WPIZ. 9/11/59.

NORTHWEST FLORIDA

"An Instantaneous Multiple Plotter," Capt. F. J. Sites, APGC, Eglin AFB. 8/11/59.

"Electronic Systems for Satellite Navigation, R. Werner, Cubic Corp. 9/15/59.

OKLAHOMA CITY

"IRE and the Space Age," Dr. Ernst Weber, President IRE. 9/24/59.

PHOENIX

"Present State of the Art of the Parametric Amplifier," Dr. H. Seidel, Bell Telephone Laboratories. 9/25/59.

QUEBEC

Guided tour of Davie Shipbuilding, Ltd. 9/19/59.

ROME-UTICA

"Management and the Engineer," Ralph I. Cole, Melpar, Inc. 9/29/59.

ST. LOUIS

"Communications Systems for Project Mercury Space Capsule," W. Benner, McDonnell Aircraft Corp. 9/22/59.

SALT LAKE CITY

"A Highly Selective I-F Amplifier," Garth Hess, Brigham Young University; "An Improved Telemetry Receiver for High Altitude Rockets," Ian Graham, University of Utah; "Velocity Response Displacement of Stable Linear Systems," Harold Vitale, University of Utah. 5/19/59.

"High Accuracy Data Acquisition," T. W. Gardner, Thiokol Chemical Corp. 6/9/59.

"IRE and the Space Age," Dr. Ernst Weber, President IRE. 9/21/59.

SAN DIEGO

"Principles and Applications of Inertial Guidance," D. C. Hiser, North American Aviation. 9/1/59.

SCHENECTADY

Guided tour and explanation of communication facilities of New York Thruway Authority. 9/22/59.

SHREVEPORT

"The Grinding, Polishing, Calibration and Finishing of Quartz Crystals," R. Freeland, International Crystal Corp. 10/6/59.

TOLEDO

"Comparison Between Electronic Industry in the U.S.A. and Germany," Helmut Seike, Kaiser Electronics. 9/10/59.

"Autolite Transistorized Ignition System," James Gage, Autolite Co. 10/8/59.

TORONTO

"Stereo Broadcasting," T. Jamroz, Northern Electric Co., and C. Eastwood, Station CFRB. 9/21/59.

TULSA

"Space Age and the IRE," Dr. Ernst Weber, President IRE. 9/25/59.

TWIN CITIES

"Tunnel Diodes: Principles and Some Applications," Dr. A. G. Tweet, General Electric Research Lab. Discussion led by S. Schulz. 9/16/59.

"Latest Developments in Jet Aircraft Electronics—Doppler Navigation," C. I. Rice. Bendix Aviation. 10/8/59.

VIRGINIA

Business Meeting. 6/11/59.

"Atmospheric Phenomena at High Altitudes," Dr. H. M. Parker. 9/25/59.

WASHINGTON

Panel Discussion: "Are You Properly Educated?" Moderated by Dr. A. H. Waynick, Penn State University with panel consisting of: Prof. G. F. Corcoran, University of Maryland; Prof. J .C. Michalowicz, Catholic University of America; Prof. E. Frank, George Washington University. 9/14/59.

WESTERN MASSACHUSETTS

"Inertial Guidance," Dr. Yachter, American Bosch Arma. 9/30/59.

Field trip to the Direct Distance Dialing Station of New England Telephone Co. at Northampton, Mass., with explanations by William Stewart of the company. 10/10/59.

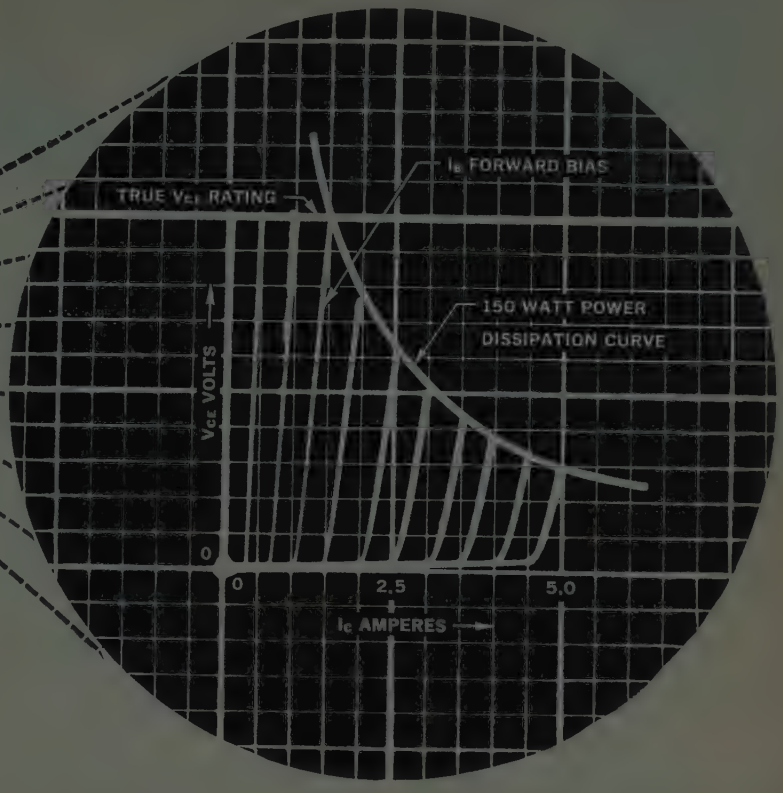
WILLIAMSPORT

Business meeting and plant tour of Sylvania Electric Products Co. with comments by W. Bresee of the company. 9/23/59.

(Continued on page 88A)

WESTINGHOUSE SILICON POWER TRANSISTORS

2N1015
2N1016



TRUE VOLTAGE RATINGS

Guaranteed by 100% power testing

This Power-voltage Test consists of testing the transistor in common emitter configuration under all bias conditions in the area defined by the *TRUE* voltage rating of the transistor (V_{CE}); the constant power dissipation curve for the transistor (150 watts); and its rated current (2 amps for 2N1015 and 5 amps for 2N1016).

The voltage at which alpha equals one, and other voltage ratings commonly given for transistors such as V_{CES}, V_{CER}, V_{CEX} and V_{CBO}, are *above* the voltage rating given to these transistors.

Each Westinghouse silicon power transistor has been completely tested throughout its rated voltage-power-current region before shipping. Thousands of transistors performing under all types of operating conditions have proved the validity of this method of *TRUE* voltage rating.

TRUE voltage ratings from 30 to 200 volts give you complete freedom in designing your equipment—you can operate Westinghouse silicon power transistors at the manufacturer's ratings without risking transistor failure. This *TRUE* voltage rating of Westinghouse silicon power transistors coupled with their still unequaled low saturation resistance and low thermal drop makes them an ideal first choice for military, industrial and commercial applications.

Type	V_{CE}*	B (min)	R_S (max)	I_C A (max)	T_j max. operating	Thermal drop to case (max)
2N1015 2N1015A 2N1015B 2N1015C 2N1015D	30 60 100 150 200	10 @I_C=2 amp	.75 ohms @I_C=2 amp I_B=300 ma	7.5	150°C	.7°C/W
2N1016 2N1016A 2N1016B 2N1016C 2N1016D	30 60 100 150 200	10 @I_C=5 amp	.50 ohms @I_C=5 amp I_B=750 ma	7.5	150°C	.7°C/W

*TRUE voltage rating (The transistors can be operated continuously at the V_{CE} listed for each rating.)

YOU CAN BE SURE...IF IT'S Westinghouse

Westinghouse Electric Corporation, Semiconductor Department, Youngwood, Pa.

New Model CRB-1B
Gertsch Complex Ratio Bridge

–measures both in-phase and quadrature voltage ratios – with high accuracy

This instrument cancels quadrature effects, giving a sharp, true null.

In eliminating quadrature voltage, this Gertsch bridge achieves an in-phase ratio accuracy as good as 0.001%. Quadrature voltage ratios are read as rectangular coordinates, tangent of phase-shift angle, or magnitude of phase-shift angle in degrees directly.

Write for complete data in Bulletin CRB.

- SELF-CONTAINED PHASE-SENSITIVE DETECTOR
- SIX-PLACE RESOLUTION
- TWO FREQUENCY RANGES
  - –30 TO 1000 CPS
  - –50 TO 3000 CPS

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THE MOST COMPLETE LINE OF COIL WINDERS BUILT

LAYER WINDERS
For random or precision layer winding, MICAFIL'S OFA and OCA series are built. Available accessories allow a set up for EVERY WINDING JOB, including winding at 18,000 rpm.

ARMATURE WINDERS
To handle every armature winding job MICAFIL offers the AWO series. Automatic, Semi-Automatic and HIGH SPEED production winders (3000 rpm) are keynoted.

STATOR WINDERS
For 4-6-8 pole three ph. stators with coils of equal pitch and with one or two coils per slot, or two pole stators having reduced winding pitch. Many other stator winding jobs are solved with the ST-1

TORROIDAL WINDERS
For standard accuracy Torroidal winding it's the RWO thru RW-III. For PRECISION POTENTIOMETER COILS the RWP will give the HIGHEST ACCURACY COILS POSSIBLE

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Swiss precision with American service

Section Meetings

(Continued from page 80A)

SUBSECTIONS

BUENAVENTURA

"Transistorized Crystal Oscillator Circuits," Dr. T. S. Amlie, NOTS, China Lake. 9/9/59.

GAINESVILLE

"The Satellite Communications Age," G. S. Shaw, Radiation Inc. 9/23/59.

KITCHENER-WATERLOO

"Video Tape Recording," W. McGregor and P. Turchan, CKCO-TV. 9/21/59.

MERRIMACK VALLEY

"Use of Educational Aids in Electronics," Dr. H. E. Stockman, Merrimack College. 10/19/59.

MONMOUTH

"International Comparison of Atomic Clocks," Dr. G. M. R. Winkler, USA Research and Development Lab., Fort Monmouth. 9/16/59.

PANAMA CITY

"Guidance Systems for Ballistic Missiles," D. R. Hagner, Bell Laboratories, Inc. 10/13/59.

SANTA ANA

"Rockets and Celestial Navigation," Dr. R. M. L. Baker, Jr., Aeronutronic Division of Ford Motor Co. 9/23/59.

SANTA BARBARA

"Modern Circuit Methods in Circuit Applications," Dr. W. K. Linvill, Rand Corp. 9/15/59.

NORTHERN VERMONT

"Ingredient 'X' and Electronic Ovens," R. B. Stem, General Electric Co., 9/29/59.

WESTCHESTER

"Automatic Programming and the Design of General Purpose Computers," Dr. J. Mauchly, Mauchly Associates. 9/16/59.

WESTERN NORTH CAROLINA

"Semi-Conductor Switching Equipment for Broad-Band Video Signals," J. W. Wentworth, RCA. 9/18/59.

Professional Group Meetings

ANTENNAS AND PROPAGATION

Orange Belt—September 16

"Electromagnetic Scattering by a Short Right Circular Cylinder at Wavelengths Long Compared with Cylinder Dimensions," T. T. Taylor, U. of California at Riverside.

AUDIO

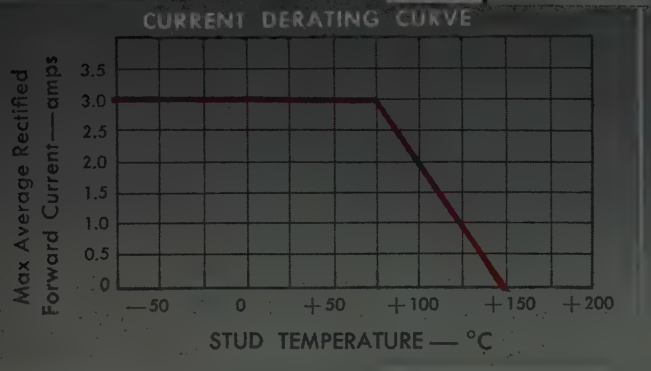
Boston—September 17

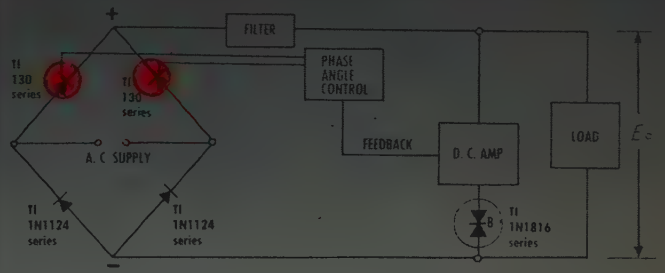
"Speech Amplification," D. L. Klepper, Bolt, Beranek & Newman.

(Continued on page 90A)

NOW FROM TI.. P N P N DIFFUSED SILICON CONTROLLED RECTIFIERS

ACTUAL SIZE





TYPICAL CONTROLLED RECTIFIER BRIDGE REGULATED POWER SUPPLY

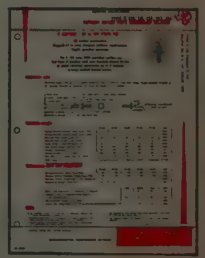
Switch 1-Ampere at 125°C Stud Temperature

Now, the high current-high temperature capabilities and new small size of the TI 130-Series permits practical use of controlled rectifiers in such applications as relays and switches in regulated power supplies, light dimmers, servo-motor controls, reversing drives and surge voltage suppression devices.

The TI diffused silicon P-N-P-N controlled rectifier has a third lead which controls current flow. A low 5-ma current fires the device which requires only 0.6 microsecond turn-on time. You get guaranteed PIV and breakover voltage ranges from 50 to 400 volts and an average rectified forward current of 3 amperes at 75°C and *1 ampere at 125°C stud temperature.* Maximum operating temperature is 150°C!

You are assured of uniform reliability through *completely diffused silicon construction* which provides higher power dissipation and high sensitivity.

Contact your local TI representative for immediate delivery of TI P-N-P-N controlled rectifiers in production quantities!



***Write** for data folder containing complete parameters on Types TI 130, 131, 132, 133, 134 Diffused Silicon P-N-P-N Controlled Rectifiers.*

Available In Hours from your local authorized TI distributor

germanium and silicon transistors
silicon diodes and rectifiers
solid tantalum capacitors
precision carbon film resistors
silicon resistors

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Instant **CONTACT IDENTIFICATION**

Identoseal **SEAL**
HERMETIC RECEPTACLES

Faster wiring, less chance of errors, reduced inspection time—these production advantages are possible only with AMPHENOL's superior Identoseals. Each contact is clearly and sharply defined—fired-on white ceramic letters contrasting strongly with the dark brown glass—both on the face and the rear of the insert.

Instant contact identification is one of many advantages of AMPHENOL Identoseals. Rugged *compression* sealing provides a tight bond between shell, glass and contacts that is extremely strong and highly resistant to thermal shock. Identoseals are capable of continuous operation at 850° F. Insulation resistance is over 100,000 megohms.

Identoseals are available in MS-type receptacles that mate with MIL-C-5015 plugs, in miniature sizes and in numerous special configurations. An engineering staff experienced in hermetic sealing can immediately meet your requirements.

"MS" Round Flange *"MS" Square Flange* *"MS" Flangeless* *"MS" Hex. Flange*

AMPHENOL **CONNECTOR DIVISION**
Amphenol-Borg Electronics Corporation

Professional Group Meetings

(Continued from page 88A)

Automatic Control

Los Angeles—September 8

"Has an Emphasis on Adaptive Control Techniques Accomplished Anything Worthwhile," R. R. Rath, U. S. Air Force.

Broadcasting

Philadelphia—October 8

"Operation of Ampex Video Tape Recorders," I. L. Ross, WFIL-TV.

Communications Systems

Oklahoma City—September 8

Main intent of the meeting was to demonstrate operation of the AAE ampex video tape recorder. The group was also conducted through all facilities of the WKY-WKY-TV operation, including their experimental operation with regard to directional operation of television stations.

Philadelphia—September 29

Field Trip Inspection of City Communication Facilities, F. Sherif, City of Philadelphia.

Electron Devices

Washington, D. C.—September 21

"Tunnel Diodes—How They work and How to Apply Them," Dr. I. A. Lesk, GE Co.

Electronic Computers

Boston—September 23

Report on the International Conference on Information Processing, J. Raffel, Lincoln Lab., A. G. Oettinger, Harvard Univ., H. Sherman, Lincoln Lab., and D. Brown, MITRE Corp.

San Francisco—September 22

"Trip to Russia and Russian Computers," M. Astrahan, IBM Corp.

Washington, D. C.—October 7

"Data Display," M. Macaulay, Data Display Inc.

Engineering Management

Rome-Utica—September 29

"Management and the Engineer," R. I. Cole, Melpar, Inc.

Washington, D. C.—September 21

"Command Management," J. C. Lackas, Industrial College of the Armed Forces.

(Continued on page 92A)

Component Specification: ARNOLD

TOROIDAL CORES

SILECTRON CORES

BOBBIN CORES

The ARNOLD LINE-UP includes ANY TAPE CORES you need

APPLICATIONS

We'll welcome your inquiries on your Tape Wound Core requirements for Pulse and Power Transformers, 3-Phase Transformers, Magnetic Amplifiers, Current Transformers, Wide-Band Transformers, Non-Linear Retard Coils, Reactors, Coincident Current Matrix Systems, Static Magnetic Memory Elements, Harmonic Generators, etc.

ENGINEERING DATA

For data on the various types of Arnold Tape Cores, write for these Bulletins:

SC-107A—*Silectron Cores, Types C, E and O*

TC-101A—*Toroidal Cores, of Supermalloy, Deltamax and 4-79 Mo-Permalloy*

TC-108A—*Bobbin Cores*

TC-113A—*Supermendur Tape Cores*

ADDRESS DEPT. P-912

Arnold produces Silectron C, E and O cores, aluminum and plastic cased toroidal cores of high-permeability materials, and bobbin-wound cores to meet whatever your designs may require in tape thickness, material, core size or weight.

As a fully integrated producer, Arnold controls every manufacturing step from the raw material to the finished core . . . and modern testing equipment permits 100% inspection of cores before shipment.

Wide selections of cores are carried in stock as standard items for quick delivery; both for engineering prototypes to reduce the need for special designs, and for production-quantity shipments to meet your immediate requirements.

• *Let us help you solve your tape core problems.* Check Arnold, too, for your needs in Mo-Permalloy or iron powder cores, and for cast or sintered permanent magnets made from Alnico or other materials. Just write or call *The Arnold Engineering Company, Main Offices, Marengo, Illinois.*

TAM-C

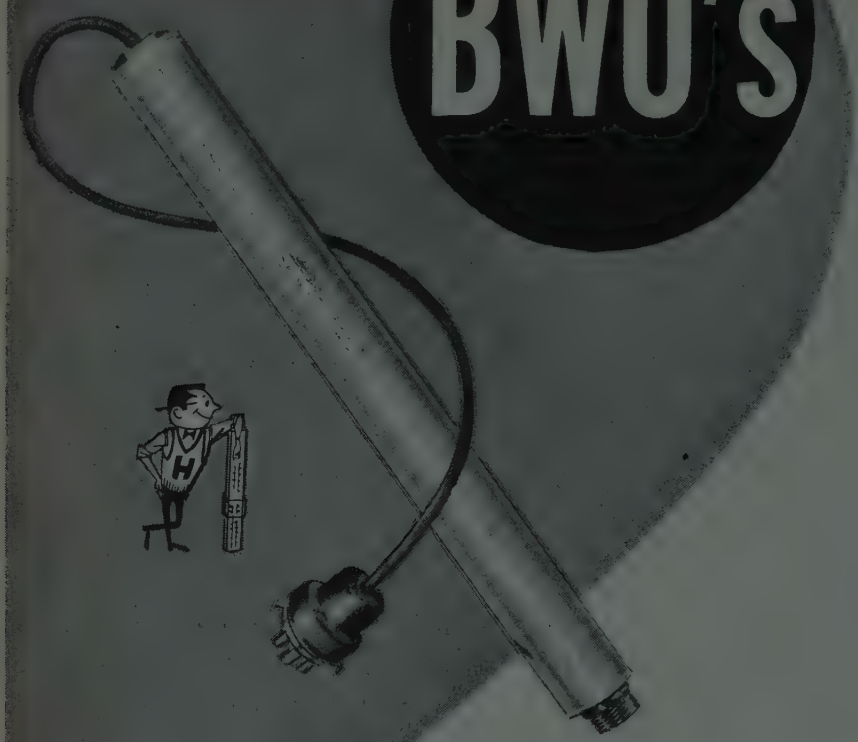
ARNOLD

SPECIALISTS in MAGNETIC MATERIALS

BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES
Find them FAST in the YELLOW PAGES

The most complete line of

BWO's



Fast Frequency Sweeping Voltage Tunable

- Wide frequency range
- Frequency adjusted by varying helix voltage
- Designed for tuning in a general voltage range of 300 to 3000 V.

Power	Frequency (KMC)							
	.5-1	1-2	2-4	3.75-7	4-8	7-11	8.2-12.4	12-18
1 mw			HO-18	HO-3	HO-13	HO-17	HO-14	HO-19
10 mw	HO-5	HO-9	HO-1	HO-20	HO-21		HO-2	HO-4

Power specified is minimum over frequency range . . generally power much higher

HUGGINS LABORATORIES, INC.

HUGGINS LABORATORIES — manufacture, development, engineering, design, research

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Professional Group Meetings

(Continued from page 90A)

Instrumentation

Los Angeles—June 3

"Biological Instrumentation," H. M. Hanish, Litton Ind.

Los Angeles—September 1

"Transducers for Instrumentation," J. Hernandez, Statham Instr.

Instrumentation Automatic Control

Long Island—September 15

"Automatic Control in the Human Body," P. Suckling, State Univ. of N. Y. (L. I. College of Medicine).

Medical Electronics

Los Angeles—September 17

"Electrosurgery; Its History, Clinical Considerations and Engineering Aspects," S. Bollas, Birtcher Corp.

"Electrosurgery; Its History, Clinical Considerations and Engineering Aspects," (covered engineering aspects) H. Finch, Birtcher Corp.

Microwave Theory and Techniques

Boston—September 16

"Parametric Amplifiers: UHF TW Amplifier Using Diodes," W. W. Mumford and R. S. Engelbrecht, Bell Telephone Labs.

Los Angeles—October 8

"The Amplitron and Its Applications," E. Shelton, Raytheon Microwave and Power Tube Div.

Washington—September 15

"A Compact Frequency Translator for Use with the Ammonia MASER," W. K. Saunders, D.O.F.L., Army Ordnance Corps.

Washington—October 13

"Comparison of Deviations from Square Law for R. F. Crystal Diodes and Barretters, G. U. Sorger, Weinschel Engr. Co.

Military Electronics

Central Florida—June 16

"1969 Astronautic Systems," M. Alperin, Office of Scientific Res. USAF.

Nuclear Science

Oak Ridge—September 17

"Status Report of Project Sherwood," E. S. Bettis, Oak Ridge National Lab.

(Continued on page 94A)

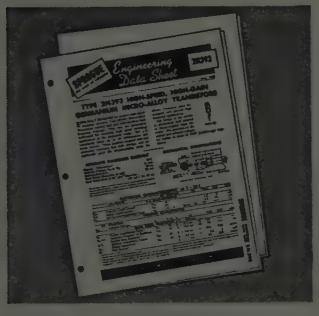
*micro-alloy transistors from SPRAGUE**

2N393

HIGH-SPEED, HIGH-GAIN MICRO-ALLOY TRANSISTORS for modern digital computer circuitry

TYPE 2N393 Micro-Alloy Transistors combine high gain with excellent high frequency response to meet the demands of high-speed computer switching applications in the megacycle range. Low saturation resistance, low hole storage, and exceptionally good life characteristics make these transistors top performers in computer circuits as well as in general high-frequency applications.

D-C β is remarkably linear up to 50 milliamperes collector current. The design of the 2N393 is particularly well adapted to direct-coupled logic circuitry. The polarities of the emitter and collector voltages are similar to those of PNP junction-type transistors.



Made by electrochemical manufacturing techniques, Sprague Micro-Alloy Transistors are uniformly reliable and very reasonably priced.

Write for complete engineering data sheets to Sprague Electric Company, 235 Marshall Street, North Adams, Massachusetts.

ACTUAL SIZE

2N393

	Min.	Typ.
h_{FE}	20	95
f_{max}	40	60

* *Sprague Type 2N393 micro-alloy transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type numbers are manufactured to the same specifications and are fully interchangeable. You have two sources of supply when you use micro-alloy transistors!*

SPRAGUE COMPONENTS:
TRANSISTORS • RESISTORS • MAGNETIC COMPONENTS
CAPACITORS • INTERFERENCE FILTERS • PULSE NETWORKS
HIGH TEMPERATURE MAGNET WIRE • CERAMIC-BASE PRINTED NETWORKS • PACKAGED COMPONENT ASSEMBLIES

SPRAGUE
THE MARK OF RELIABILITY

NEW FROM NARDA

MICROWAVE MODULATOR

accepts over 40 magnetrons!

Here's the first of a series of new products from Narda's recently-established High Power Electronics Division! A high power Microwave Modulator that permits installation **inside the unit** of any of more than 40 magnetrons! Complete, compact and self-contained, it accepts magnetrons covering 3,200 mc to 35,000 mc, with peak outputs from 6 KW to 120 KW. Model 10001 features a completely interlocked circuit, with all high voltage leads and connections **internal**, for maximum safety; solid state high voltage bridge rectifiers for longer life and reduced heat output (prolonging life of other components, too); and built-in meters and viewing connectors for all principal parameters.

Other features are shown below. For complete specs and a list of at least 40 magnetrons suitable for use with the 10001, write Narda's High Power Electronics Division (HPED) at Dept. PIRE-7.

SPECIFICATIONS

High voltage supply: Continuously variable from 0 to 4 KV at 100 ma; **Pulse power:** 18 KV at 20 amps max.; **Magnetron filament supply:** Cont. variable from 0 to 13 volts at 3 A; **Rep. rate generator range:** Cont. variable from 180 to 3000 pps; **Pulse width:** 1 microsecond at 70% points, rise time 0.15 microseconds, max. slope 5% (other pulse widths available); **Size:** 38" h, 22" w, 18" d. **Weight:** 150 lbs.

Complete 1959 catalog available on request.

the narda microwave corporation
HIGH POWER ELECTRONICS DIVISION
118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

Professional Group Meetings

(Continued from page 92A)

Production Techniques

Los Angeles—September 24

"Packaging Ferrite Cores for Military Applications," D. Slotnick, R. Igram and H. Chrystie, Telemeter Magnetics, Inc.

San Francisco—September 22

"Production Planning in Rapidly Growing Electronic Factories," 1) W. McGinnitty, Ampex Corp., 2) G. M. Eustachy, Beckman/Berkeley, 3) O. Landeck, Electro Engrg. Works.

Radio Frequency Interference

Washington, D. C.—June 10

"Shortcomings of Interference Specifications," C. F. W. Anderson, Martin Co.

Space Electronics and Telemetry

Central Florida—January 29

"New Telemetry Techniques," L. Rauch, U. of Michigan.

Central Florida—May 21

"IRIG Standards for PCM Telemetry," E. E. Ollikkala, RCA Missile Proj.

"Renaming of Professional Group on Telemetry and Remote Control to Space Electronics and Telemetry," C. H. Hoeppner, Radiation, Inc.

Central Florida—June 23

"2200 Megacycle Telemetry," P. Richardson, WADC.

Detroit—September 18

"Global Communications by Means of Satellites," J. B. Wiesner, M.I.T.

Vehicular Communications

Baltimore—September 22

"New Transistorized Progress Line (General Electric)," R. T. Myers, GE Co.

Philadelphia—September 29

Field Trip Inspection of City Communication Facilities, F. Sherif, City of Philadelphia.

Washington—September 29

"Tape-Recorded Address on Status of Geneva Radio Conference," W. H. Watkins, FCC.

"Elaboration on Geneva Radio Conference," J. M. Kittner, McKenna and Wilkinson.

SIX VSWR AMPLIFIER FEATURES

...available only from NARDA

1. Battery-operated (rechargeable nickel-cadmium).
2. Completely transistorized for low current drain.
3. Independent of line voltage variations.
4. Complete bolometer protection during switching.
5. Most compact unit available.
6. Completely portable.

Model 441B—$225

Now you can get a completely portable battery-operated VSWR Amplifier offering complete protection against bolometer burnout at the same time!

Narda's Model 441B is supplied with nickel-cadmium batteries, providing complete freedom from line voltage deviations. Batteries recharge automatically when unit is plugged in; provision is built-in to show state of battery charge. A special protective circuit permits switching and connect-disconnect with no danger of bolometer burnout. Provision is made for both crystals and high **and** low current bolometers.

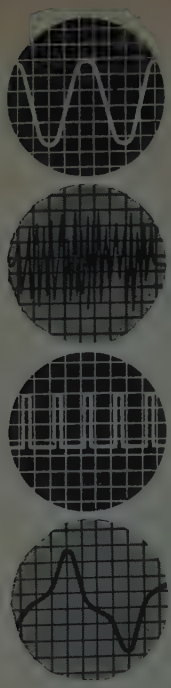
Full sensitivity is provided over both normal and expanded scales; eliminates switching attenuation range. Other features are shown on this page; for complete information and a free copy of our latest catalog, write to us at: Department PIRE-10.

FEATURES:

- **SENSITIVITY:** 0.1 microvolts at 200 ohms for full scale.
- **FREQUENCY:** 1,000 cps ± 1% (plug-in frequency networks available for 315-4,000 cps and broad-band applications)
- **BANDWIDTH:** 25-30 cps
- **RANGE:** 72 db (60 db in 10 db steps, 11 db continuous)
- **ACCURACY:** ± 0.1 db per step • ± 0.2 db maximum cumulative • meter linearity: 1% of full scale

the narda microwave corporation

118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650



TRUE RMS

frequency range 5 to 500,000 cps

FEATURES

Built-in calibrator . . . easy-to-read 5 inch log meter . . . immunity to severe overload . . . useful auxiliary functions

SPECIFICATIONS

VOLTAGE RANGE: 100 microvolts to 320 volts
DECIBEL RANGE: —80 dbv to +50 dbv
FREQUENCY RANGE: 5 to 500,000 cycles per second
ACCURACY: 3% from 15 cps to 150KC; 5% elsewhere. Figures apply to *all* meter readings
MAXIMUM CREST FACTORS: 5 at full scale; 15 at bottom scale
CALIBRATOR STABILITY: 0.5% for line variation 105-125 volts
INPUT IMPEDANCE: 10 MΩ and 25 μμf, below 10 millivolts; 10 MΩ and 8μμf above 10 millivolts
POWER SUPPLY: 105-125 volts; 50-420 cps, 75 watt. Provision for 210-250 volt operation

measures from

100 MICROVOLTS to 320 VOLTS

regardless of waveform

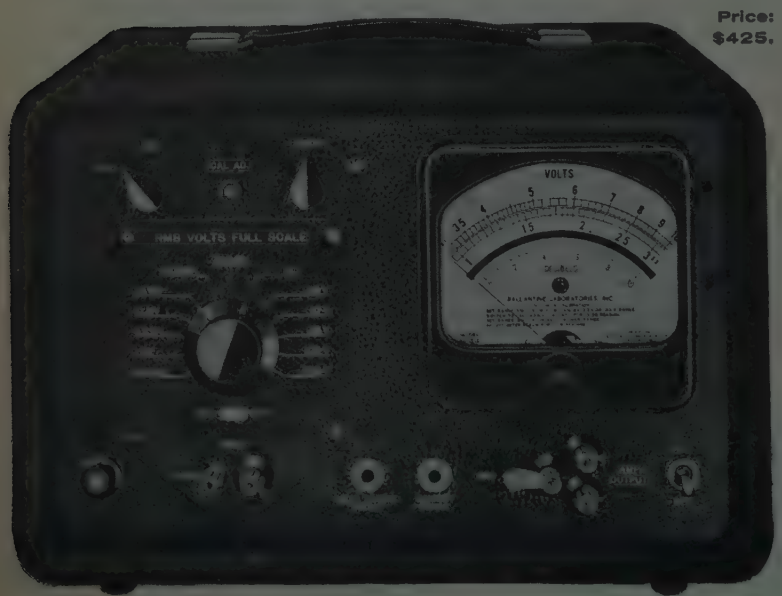
DIMENSIONS: *(Portable Model)* 14⅜" wide, 10⅛" high, 12⅜" deep—Relay Rack Model is available
WEIGHT: 21 lbs., approximately

Write for catalog for complete information

BALLANTINE VOLTMETER Model 320

Manufacturers of precision Electronic Voltmeters, Voltage Calibrators, Capacitance Meters, DC-AC Inverters, Decade Amplifiers, and Accessories.

Price: $425.



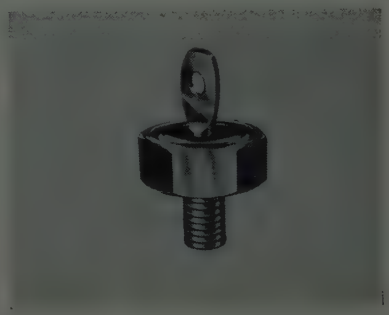
BALLANTINE LABORATORIES, INC. BOONTON NEW JERSEY

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 48A)

Zener Diodes

**U. S. Semiconductor Products, a Division of Topp Industries, Inc., 3540 West Osborn Rd., Phoenix, Ariz., announces the industry's first 35-watt zener diode, according to J. C. Worth, Jr., vice president-sales. The new line comprises single diffused silicon junction zeners with voltages ranging from 8.2 to 100 volts and rectifiers with PIVs from 50 to 600 volts.



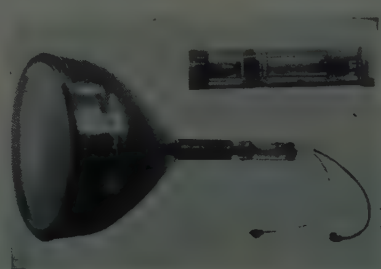
The rectifiers feature high forward conductance, with forward current up to 40 amperes at 1 volt, and 1 ma saturation current at rated PIV.

According to Worth, these diodes are built with matched coefficients of expansion which prohibit separation of internal lead wire and silicon wafer, even under extreme thermal shock. They are not position-sensitive and are resistant to vibration. These hermetically sealed diodes have plated copper heat sink and to provide thermal conduction.

Technical details may be obtained by writing to the firm.

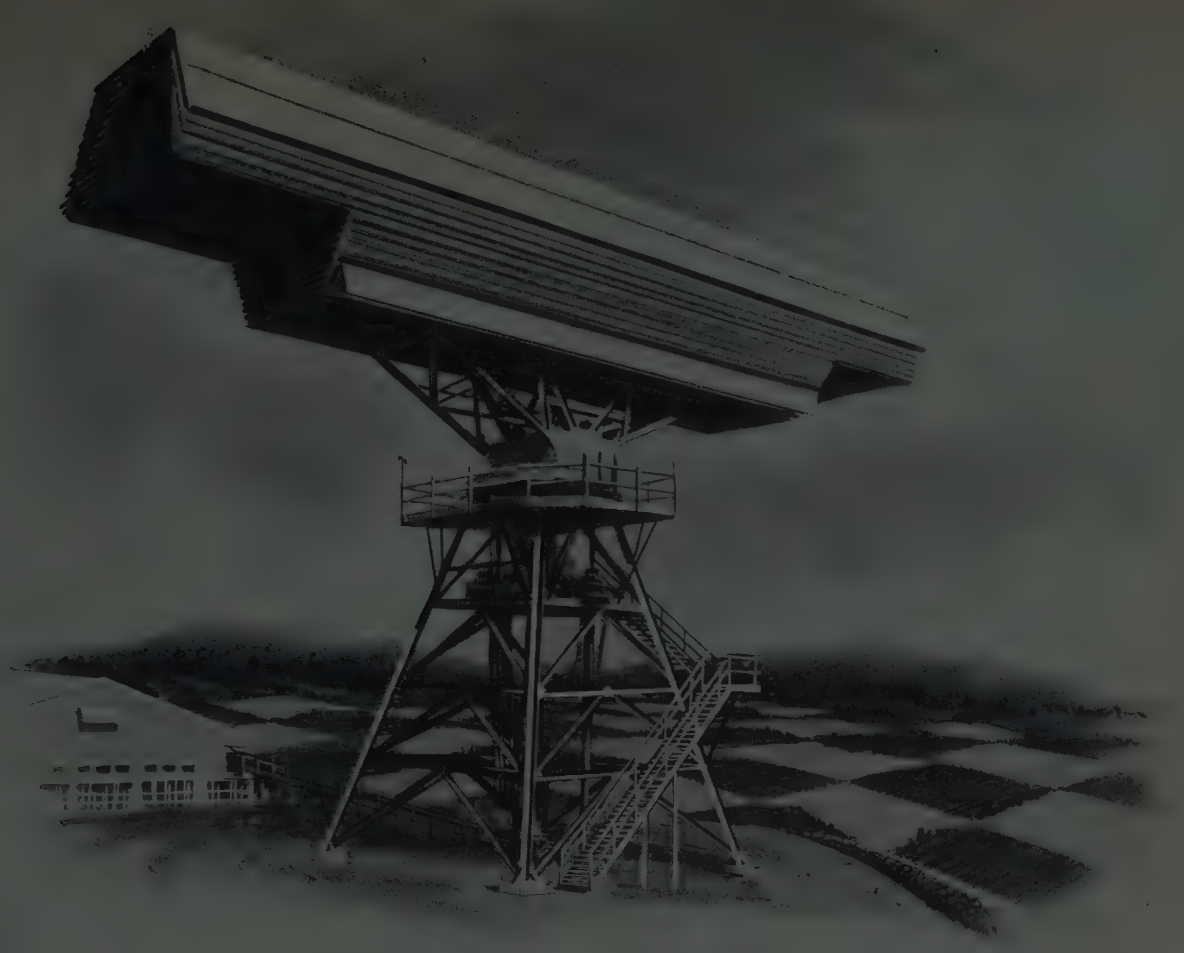
Microwave Frequency C-R Tube Display

The development of a newly designed, compact "Wamoscope," a cathode ray tube capable of presenting microwave frequency information directly on its screen, was announced today by **Sylvania Electric Products Inc.**, 730 Third Ave., New York 17, N. Y., subsidiary of General Telephone & Electronics Corp.



The insert shows the signal coupler which incorporated within the neck of the tube envelope. The new tube, which was

(Continued on page 98A)



CHESSMAN . . . 1960

New orders of power through Amplitron transmitter application. New frequency areas. Ferrite mechanisms. Sophistication in receiving and data processing techniques. This is advance technology at Raytheon Heavy Electronics.

Developments in such areas are already incorporated in these Heavy Electronic long range radars, ordnance and communications systems:

AN/FPS-28 800-ton warning system for SAGE network.
96-voice channel pulse-code-modulation equipment.
Two-gun MEMRAD Bright Display.
AN/SPG-51 radar for Tartar Missile fire control system.

Each development evolved from imagination . . . technical command . . . experience — the qualities we always seek.

Select positions may be investigated by writing: Mr. Donald H. Sweet, Executive & Engineering Placement, Raytheon, 624 X Worcester Road, Framingham, Mass. (suburban Boston).

HEAVY ELECTRONIC

GOVERNMENT EQUIPMENT DIVISION

RAYTHEON

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Give your products
MORE RELIABILITY and
BETTER PERFORMANCE with
FREED
QUALITY

Ruggedized,
MIL STANDARD
POWER & FILAMENT TRANSFORMERS
Primary 105/115/125 V 50-60~

Cat. No.	Appl.	MIL Std.	MIL Type
MGP 1	Plate & Fil.	90026	TF4RX03HA001
MGP 2	Plate & Fil.	90027	TF4RX03JB002
MGP 3	Plate & Fil.	90028	TF4RX03KB006
MGP 4	Plate & Fil.	90029	TF4RX03LB003
MGP 5	Plate & Fil.	90030	TF4RX03MB004
MGP 6	Plate	90031	TF4RX02KB001
MGP 7	Plate	90032	TF4RX02LB002
MGP 8	Plate	90036	TF4RX02NB003
MGF 1	Filament	90016	TF4RX01EB002
MGF 2	Filament	90017	TF4RX01GB003
MGF 3	Filament	90018	TF4RX01FB004
MGF 4	Filament	90019	TF4RX01HB005
MGF 5	Filament	90020	TF4RX01FB006
MGF 6	Filament	90021	TF4RX01GB007
MGF 7	Filament	90022	TF4RX01JB008
MGF 8	Filament	90023	TF4RX01KB009
MGF 9	Filament	90024	TF4RX01JB012
MGF 10	Filament	90025	TF4RX01KB013

Ruggedized,
MIL STANDARD
AUDIO TRANSFORMERS

Cat. No.	Imped. level–ohms	Appl.	MIL Std.	MIL Type
MGA 1	Pri. 10,000 C.T. Sec. 90,000 Split & C.T.	Interstage	90000	TF4RX15AJ001
MGA 2	Pri. 600 Split Sec. 4, 8, 16	Matching	90001	TF4RX16AJ002
MGA 3	Pri. 600 Split Sec. 135,000 C.T.	Input	90002	TF4RX10AJ001
MGA 4	Pri. 600 Split Sec. 600 Split	Matching	90003	TF4RX16AJ001
MGA 5	Pri. 7,600 Tap @ 4,800 Sec. 600 Split	Output	90004	TF4RX13AJ001
MGA 6	Pri. 7,600 Tap @ 4,800 Sec. 4, 8, 16	Output	90005	TF4RX13AJ002
MGA 7	Pri. 15,000 C.T. Sec. 600 Split	Output	90006	TF4RX13AJ003
MGA 8	Pri. 24,000 C.T. Sec. 600 Split	Output	90007	TF4RX13AJ004
MGA 9	Pri. 60,000 C.T. Sec. 600 Split	Output	90008	TF4RX13AJ005

MIL Transformers are available from stock.

Write for further information on these units or special designs.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.
1720 Weirfield Street
Brooklyn (Ridgewood) 27, New York

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 96A)

developed for use in advanced electronic systems applications, does not require a solenoid, a bulky focusing structure requiring an external source of electric current. The "Wamoscope" is only slightly longer than conventional television tubes.

The improved "Wamoscope" operates over a frequency range of 2 to 10 kmc, and will be particularly important in high-resolution radar applications. The new tube has a signal coupler incorporated within the tube en elope and "spot size" has been improved to 160 lines per inch at the center of its 10-inch screen. Sylvania developed the original "Wamoscope" in 1956 in conjunction with the U. S. Naval Research Laboratory.

Mercury-Wetted Contact Relays

A full-line of Clare mercury-wetted contact relays is pictured and described in a new catalog just issued by **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill., manufacturer of relays and allied electronic devices.

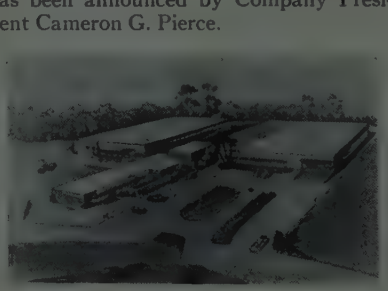
Relay types are for both single-and multi-element operation, biased with permanent magnets, or adjustable to provide single-side-stable, bi-stable, or chopper characteristics.

These relays provide long operating life . . . over 8 billion operations and are still going on a 4-year test. Basic element is a magnetic switch, sealed in a glass capsule which is filled with pressurized hydrogen. With every make and break, the mercury-film contact surface is renewed by capillary action, like a lamp wick. As a result, contacts never wear out, never chatter or bounce, and require no maintenance whatsoever.

For a copy of Catalog 201 contact the firm.

New Ling-Altec Plant

A $600,000 expansion of the **Ling-Altec Electronics** plant in Anaheim, California has been announced by Company President Cameron G. Pierce.



Pierce said that the enlarged facility, which will include one new manufacturing building, will provide approximately

(Continued on page 100A)

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for an immediate demonstration or delivery of Simpson Laboratory Test Equipment.

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INGLEWOOD, ORegon 8-0441

ELECTRONIC SUPPLY CORPORATION
2085 East Foothill Blvd.
PASADENA, SYcamore 5-5901

COLORADO
WARD TERRY & COMPANY
70 Rio Grande Blvd.
DENVER, AMherst 6-3181

GEORGIA
ELECTRO TECH EQUIPMENT COMPANY
690 Murphy Avenue S.W.
ATLANTA 10, PLaza 3-4128

ILLINOIS
ALLIED RADIO CORPORATION
100 N. Western Avenue
CHICAGO 80, HAymarket 1-6800

NEWARK ELECTRIC COMPANY
223 W. Madison Street
CHICAGO 6, STate 2-2944

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RADIO SPECIALTIES COMPANY
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MINNESOTA
NORTHWEST RADIO & ELECTRONICS SUPPLY CO.
52 South Twelfth Street
MINNEAPOLIS 3, FEderal 9-6346

GOPHER ELECTRONICS COMPANY
370 Minnesota Street
SAINT PAUL 1, CApitol 4-9666

MISSOURI
SCHERRER INSTRUMENTS
5449 Delmar Blvd.
ST. LOUIS, FOrest 7-9799

NEW YORK
STACK INDUSTRIAL ELECTRONICS, INC.
25 Susquehanna Street
BINGHAMTON, Phone: 3-6326

ELECTRONICS CENTER INCORPORATED
211 West 19th Street
NEW YORK 11, ALgonquin 5-4600

HARRISON RADIO CORPORATION
225 Greenwich Street
NEW YORK 7, BArclay 7-7777

NORTH CAROLINA
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414 Hillsboro Street
RALEIGH, TEmple 3-1936

DALTON-HEGE RADIO SUPPLY CO., INC.
938 Burke Street
WINSTON SALEM, Phone: 5-8711

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PIONEER ELECTRONICS SUPPLY CO.
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CONSOLIDATED RADIO COMPANY
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PHILADELPHIA 6, WAlnut 5-7871

SOUTH CAROLINA
CAROLINA RADIO SUPPLY CO., INC.
221 W. Washington Street
GREENVILLE, CEdar 2-6740

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ENGINEERING SUPPLY COMPANY
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DALLAS 35, FLeetwood 7-6121

MIDLAND SPECIALTY COMPANY
500 W. Paisano Drive
EL PASO, KEystone 3-9555

BUSACKER ELECTRONIC EQUIP. CO., INC.
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HOUSTON 19, JAckson 9-4626

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ODESSA, Phone: 7-7212

DON'T INVEST IN TEST EQUIPMENT 'TIL YOU COMPARE FEATURES WITH THE

NEW Simpson LABORATORY LINE

PULSE GENERATOR . . . model 2620

No Other Unit Offers Such Accuracy, Versatility, and Set-Up Speed Within This Price Range

Twin meters read pulse repetition frequency and pulse duration simultaneously. Rise time is 0.02 microseconds; decay time, 0.03 microseconds. Pulse duration, continuously variable from 0.1 to 1000 microseconds. Jitter, less than 0.005 microseconds. Pulse repetition rate, continuously variable from 10 to 100,000 pps in four ranges. Price **$625**

WRITE FOR COMPLETE SPECIFICATIONS

WIDE-BAND OSCILLOSCOPE . . . model 2610

For the 1001 Jobs Where You Don't Need an Expensive Specialized Scope

Here's a high-gain scope that makes your test equipment appropriation go farther. Vertical sensitivity, 6 mv RMS. Vertical calibration accuracy, ± 3%. Response (linear position): DC to 5.0 mc/sec, ± 0.5 db; DC to 8.0 mc/sec, ± 1.5 db. Response (transient position): DC to 3.5 mc/sec, –3 db, and –6 db at 5.0 mc/sec. Triggered and recurrent sweeps. Precalibrated sweep positions of 5, 50, 500, 5000 microseconds. Price **$575**

WRITE FOR COMPLETE SPECIFICATIONS

LABORATORY STANDARD

VOLT-OHM-MILLIAMMETER . . . model 2600

A Self-Powered Calibrator for Electrical Instrument Maintenance and High Accuracy Testing

Two terminal connections cover all 49 ranges for unusually fast operation. DC accuracy is ± 0.5% F.S.; AC, ± 0.75% F.S. (at 77°F, 25°C). Separate meters (*self shielded* movements) for DC and AC readings. Price. **$1620**

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AVAILABLE FROM MANY INDUSTRIAL ELECTRONIC DISTRIBUTORS, COAST-TO-COAST
Write to Factory for Details

MANUFACTURERS OF ELECTRONIC TEST EQUIPMENT FOR OVER 50 YEARS

Simpson ELECTRIC COMPANY

5204 West Kinzie St., Chicago 44, Illinois • Telephone: EStebrook 9-1121
In Canada: Bach-Simpson Ltd., London, Ontario

BENDIX SR RACK AND PANEL CONNECTOR

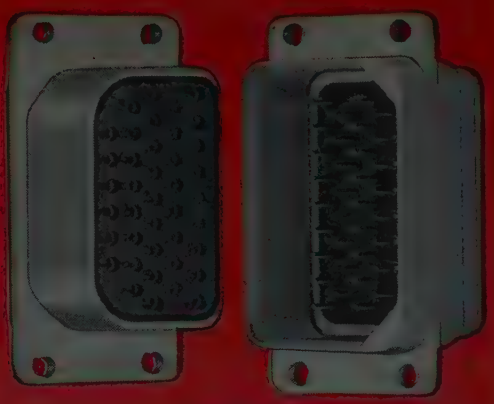
with outstanding resistance to vibration

The Bendix type SR rack and panel electrical connector provides exceptional resistance to vibration. The low engagement force gives it a decided advantage over existing connectors of this type.

Adding to the efficiency of this rack and panel connector is the performance-proven Bendix "clip-type" closed entry socket. Insert patterns are available to mate with existing equipment in the field.

Available in general duty, pressurized or potted types, each with temperature range of −67°F to +257°F.

Here, indeed, is another outstanding Bendix product that should be your first choice in rack and panel connectors.



FEATURES:

Resilient Insert • Solid Shell Construction • Low Engagement Forces • Closed Entry Sockets • Positive Contact Alignment Contacts—heavily gold plated Cadmium Plate—clear Irridite finish • Easily Pressurized to latest MIL Specifications.

SCINTILLA DIVISION
SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

Export Sales and Service: Bendix International Div., 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliates: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.
Factory Branch Offices: Burbank, Calif.; Orlando, Florida; Chicago, Illinois; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

DESIGN-IN Production Reliability

Specify US SEMCOR

Single Diffused Silicon Junction
MEDIUM POWER
RECTIFIER DIODES

PIVs from 50 to 700 volts, extremely high forward conductance, minimum saturation current. 1N1907 through 1N1924 series.

U. S. SEMICONDUCTOR PRODUCTS
A DIVISION OF TOPP INDUSTRIES, INC.
3540 WEST OSBORN ROAD, PHOENIX, ARIZONA

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 98A)

65,000 additional square feet of plant area on the company's 13-acre site near Harbor Boulevard and the Santa Ana Freeway at 1515 South Manchester.

The company will move its Culver City plant, which manufactures high power vibration test equipment and sonar components, to the Orange County site, which is the main plant of the Altec companies subsidiary of Ling-Altec Electronics Corp.

Approximately 450 persons will be employed in the facility.

Transformer Brochure

A new 4-page brochure, "Encapsulated Transformer," describes performance characteristics and applications of patented HR/Epseal and Electroseal transformer constructions. Three basic design improvements, which achieve higher reliability, reduced size and weight, and improved cooling, are illustrated along with photographs of typical transformer configurations. Units are designed to custom requirements from microwatt ratings to 250 kva for both commercial and Mil-T-27A (Grade 2 or 5) applications.

For free copy write to Rex Brooks, Sales Manager, **Electro Engineering Works,** 401 Preda St., San Leandro, Calif.

Use your IRE DIRECTORY! It's valuable!

Aune Named SM of Burndy Omation Div.

Alan E. Aune has been named sales manager of the **Omaton division of Burndy Corp.,** Norwalk, Conn., it was announced by S. D. Bergman, director of sales.

Aune's background in sales, service and production includes 11 years with the Cities Service Oil Co. and the United Motors division of General Motors as an automotive engineer specializing in electrical systems. He then served the United States Rubber Company as production supervisor in the munitions and the wire and cable divisions and as manager of automotive and aircraft sales.

Since joining Burndy in 1949, he has been manager of automotive sales and of ordnance sales, and OEM sales manager.

(Continued on page 104A)

CONSIDER...

Products shown are twice actual size

Lockheed for electronic ceramics

The research, development and manufacture of miniature electronic ceramic components is centered in the new Electronic Ceramics Laboratory at Lockheed Electronics and Avionics Division (LEAD).

This facility is fully able to provide electronic ceramics to meet your particular specifications: MEMORY CORES, a whole family of square loop cores to suit computer and shift register applications: MULTI-APERTURE DEVICES (MAD), Cavitron equipment for the volume production of any geometry of MAD; RECORDING HEADS, of very dense materials with high flux density ground to a micro-finish; GARNETS, poly-crystalline yttrium-iron garnets with minimum line width and loss tangent; ALUMINA SUBSTRATES, of high mechanical strength, high electrical resistivity and low dielectric loss; CUP CORES, in any size to specified inductance and minimum temperature coefficient; HIGH "Q" MATERIALS, for use as inductors, tuning slugs, transformers—frequency ranges from 1 to 50 megacycles.

What are your requirements? Write... Marketing Branch, 6201 E. Randolph Street, Los Angeles 22, California. Telephone OVerbrook 5-7070.

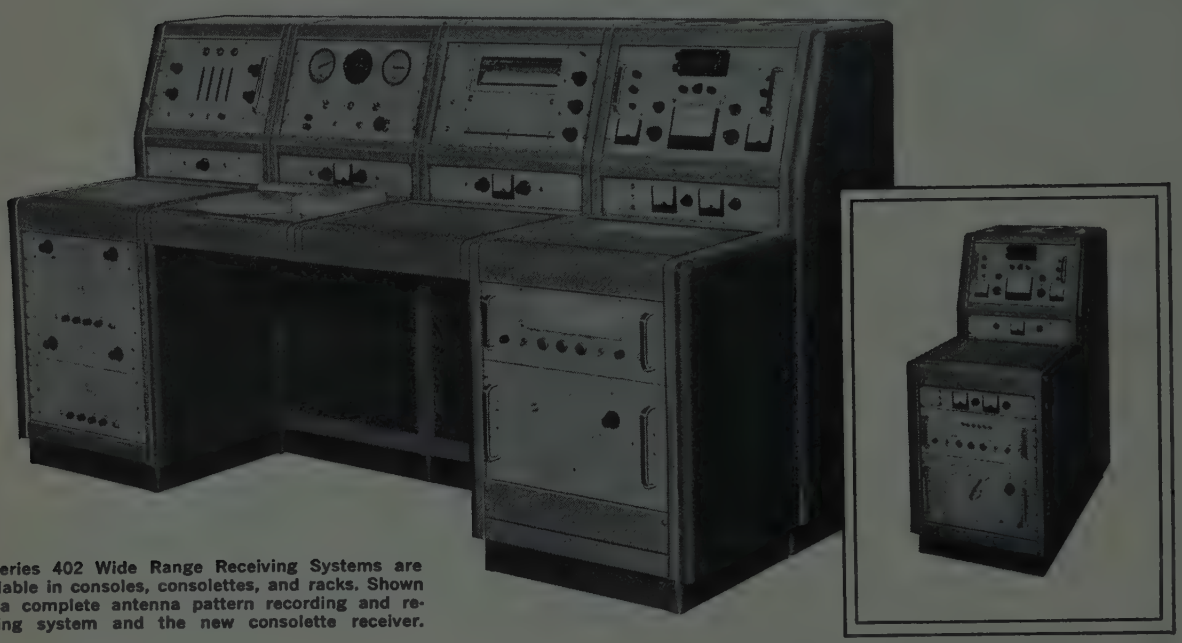
Look to Lockheed for LEADership *in Electronics*

LOCKHEED ELECTRONICS & AVIONICS DIVISION

Requirements exist for staff and supervisory engineers

MAJORS and MINORS

...A Message to the Antenna Designer



● Series 402 Wide Range Receiving Systems are available in consoles, consolettes, and racks. Shown are a complete antenna pattern recording and receiving system and the new consolette receiver.

A crowded spectrum plus high power radar and communication systems critically compound the problems of the antenna design engineer.

More than ever, the complete pattern including **all** the major and minor lobes of every radiating element must be graphed for sound engineering evaluation.

S-A Receiver Gets the Whole Signal

Scientific-Atlanta Series 402 Wide Range Receiving Systems are specifically designed for antenna pattern measurements. Unique in design, these receivers combine maximum sensitivity and linearity from 30 mc to above 100 kmc. They are also useful as multipurpose laboratory instruments for microwave testing, monitoring, and measuring applications.

Only from S-A, 1 db Linearity over Full 60 db Dynamic Range

A recent development, S-A's P-4 modification adds 20 db to the normal 40 db dynamic range. The modification takes advantage of the gain vs AGC voltage characteristics of the Series 402. Existing receivers can be modified at the factory.

New Modification Z Broadens Use

Modification Z adds a precision IF attenuator and VTVM to the Series 402. Now RF and microwave signal level, gain, and isolation measurements can be made with fewer components and instruments. *For instance,* an X band 80 db attenuator can be calibrated to within ±0.5 db with a 1 mw signal source, a flap attenuator, a mixer, and an S-A Series 402Z Receiver. Antenna gain can be measured by direct comparison with a standard gain antenna. Signal levels can be compared against a reference standard.

Other Features

One coaxial cable from antenna to receiver eliminates costly lossy waveguides and rotary joints. Antenna can be located up to 75 feet away with negligible loss in sensitivity ☆ One receiving system covers 30 mc to above 100 kmc without plug-ins ☆ Reception of cw signals from simple sources eliminates need for precise modulation ☆ High sensitivity means low source power and long ranges ☆ High selectivity reduces interference and cross talk between adjacent test ranges ☆ Positive AFC action over full dynamic range provides pattern recording in deep nulls.

PRICES

Series 402, 2 to above 100 kmc	$7500
Series 402A, 2 to above 100 kmc with AGC	8000
Series 402B, 30 mc to above 100 kmc	8500
Series 402C, 30 mc to above 100 kmc with AGC	9000
Modification P-4	500
Modification Z	1000

NEW DATA FOLDER READY

For complete information ask for our new data folder from your nearby S-A engineering representative or write directly to Box 4312.

SCIENTIFIC-ATLANTA, INC.

2162 PIEDMONT ROAD, N. E.
ATLANTA 9, GEORGIA
PHONE: TRinity 5-7291

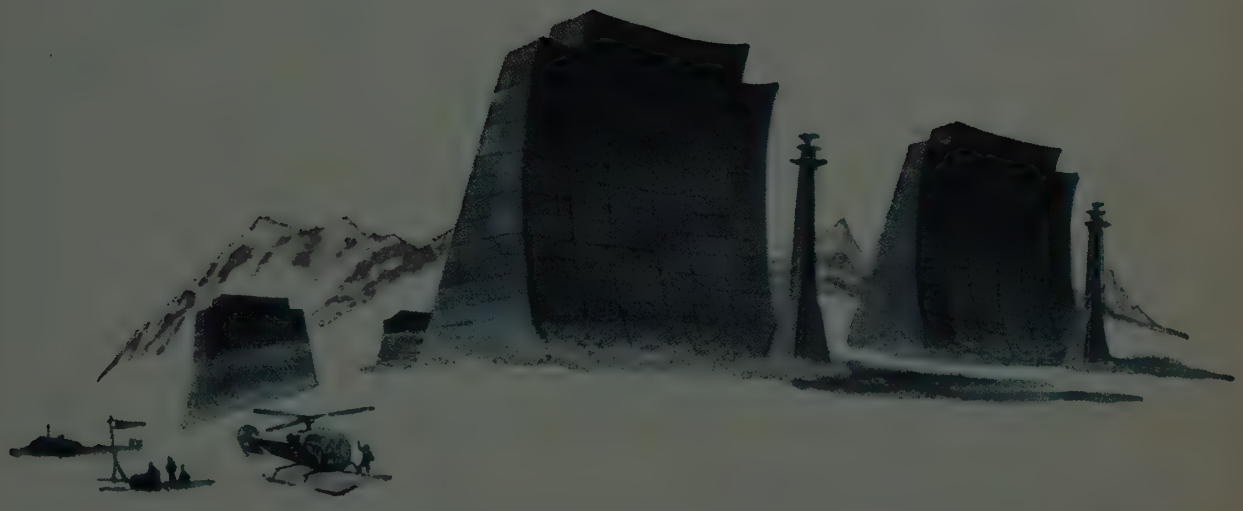
3

THE 'DO' LINE THAT TELLS AGGRESSORS, 'DON'T!'

Because the tropo scatter radio equipment of Radio Engineering Laboratories, Inc., has proved its worth in installations around the world, it is also specified for the U.S. Air Force's DEW-East—the vital DEW Line extension from the present terminal on Baffin Island 1,200 miles east to Iceland. Once again, Western Electric Co., Inc., has chosen REL apparatus for this "can do" communications system to bridge the gap of ice and open water, and overcome the plagues of atmospheric and electromagnetic disturbances.

It's the unequalled reliability of REL equipment which has made it the choice for eight of the nine major networks in operation or on order. In fact, more kilowatt miles of REL tropo apparatus are in use or on order than those of all other companies combined.

The hazards of snow, ice and weather that make construction of DEW-East stations so formidable for the men who build them, call for equipment with the same sturdiness, the background of experience, the same quality of "can do". That's REL. And that's why you'll want REL's help in solving your specialized radio problems.



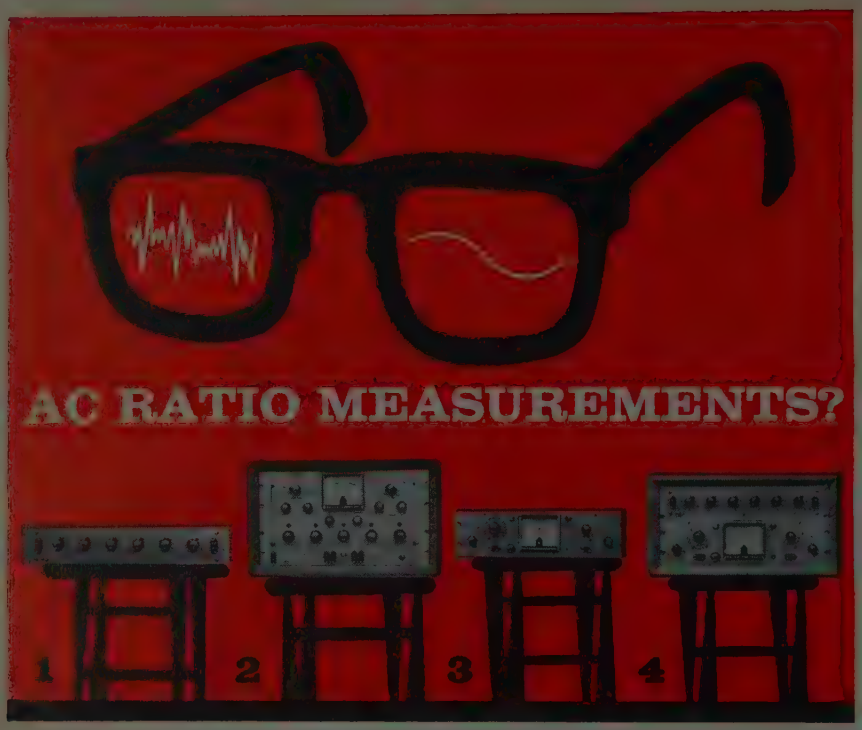
Radio Engineering Laboratories · Inc

A subsidiary of Dynamics Corporation of America

Dept. I · 29-01 Borden Ave · Long Island City 1, NY

REL

Creative careers at REL await a few exceptional engineers. Address résumés to James W. Kelly, Personnel Director



THERE'S A NORTH ATLANTIC INSTRUMENT TO MEET YOUR REQUIREMENTS, TOO...

Now—from North Atlantic—you get the complete answer to AC ratio instrumentation problems—in the laboratory, on the production line, in the field.

Specialists in ratiometry, North Atlantic offers the only complete line of precision instruments to handle any ratio measurement task. All are designed to meet the most demanding requirements of missile age electronics—provide high accuracy, flexibility. component compatability and service-proven perforformance. Some are shown above.

If your project demands total solution to ratio measurement problems, write for Date File No. 10D. It provides complete specifications and application data and shows how North Atlantic's unparalleled experience in ratiometry can help you.

1. RATIO BOXES:	2. COMPLEX VOLTAGE RATIOMETERS	3. PHASE ANGLE VOLTMETERS	4. RATIO TEST SETS
Both laboratory standards and general duty models. Ratio accuracies to 0.0001%. Operation from 25 cps to 10 kc.	Integrated, single-unit system for applications where phase relations are critical. Accuracy to 0.0001%, unaffected by quadrature. Three frequency operation. Direct reading of phase shift in milliradians or degrees.	Versatile readout system for all ratiometry applications, providing direct reading of phase, null, quadrature, in-phase and total voltage. Broadband, single-, or multiple-frequency operation.	Ratio reference and readout in one convenient package for production line and similar applications. Can be supplied with any desired combination of ratio box and phase angle voltmeter.

NA

NORTH ATLANTIC INDUSTRIES, INC.
603 MAIN STREET, WESTBURY, N.Y. • EDGEWOOD 4-1122

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 100A)

Peak Responding Voltmeter

A new peak responding Voltmeter, Model 305A, is announced by **Ballantine Laboratories,** Boonton, N. J. The new instrument measures peak or peak-to-peak values of any repetitive waveforms—distorted or undistorted sine-waves, or pulses, Its operating mode can be selected to respond to a peak-to-peak and positive or negative peak of the waveform.

The dc component of the waveform is not measured by the instrument.

The frequency range when measuring sinewaves extends from 5 cps to 500 kc., but distorted waveforms with harmonics extending up to 2 mc, however, can also be measured. Pulses with duration from 0.5 μsec to 5 μsec and with a repetition rate from 5 to 500,000 pps can also be measured.

The accuracy is 2 to 5% depending on the waveform measured. The precision of the reading is better than 0.5% at any part of the scale.

The Model 305A can be used as a wideband amplifier with a gain of 86 db and a source impedance of approximately 3 ohms in series with 0.22 μf. The maximum output voltage from amplifier is 150 volts pp. The amplifier output is intended to be used for waveform monitoring only into loads above 30,000 ohms and below 10 $\mu\mu$f.

The instrument has a magnetically regulated power transformer in addition to an electronically regulated power supply.

Microwave Waveguide Ferrite Isolators

Latest issue of "new From PRD," describes PRD 1203–1209 Ferrite Isolators which are specially designed to offer maximum isolation and minimum insertion loss over a frequency range of 3.95 to 26.5 kmc.

The two page bulletin gives typical performance curves which show VSWR, isolation and insertion loss plotted over the isolators' entire frequency range.

These ferrite isolators are conservatively rated at 5 watts, but can dissipate

(Continued on page 108A)

NOW...every volume tester of semiconductor devices can profit with SMART

(TI's Sequential Mechanism for Automatic Recording and Testing)

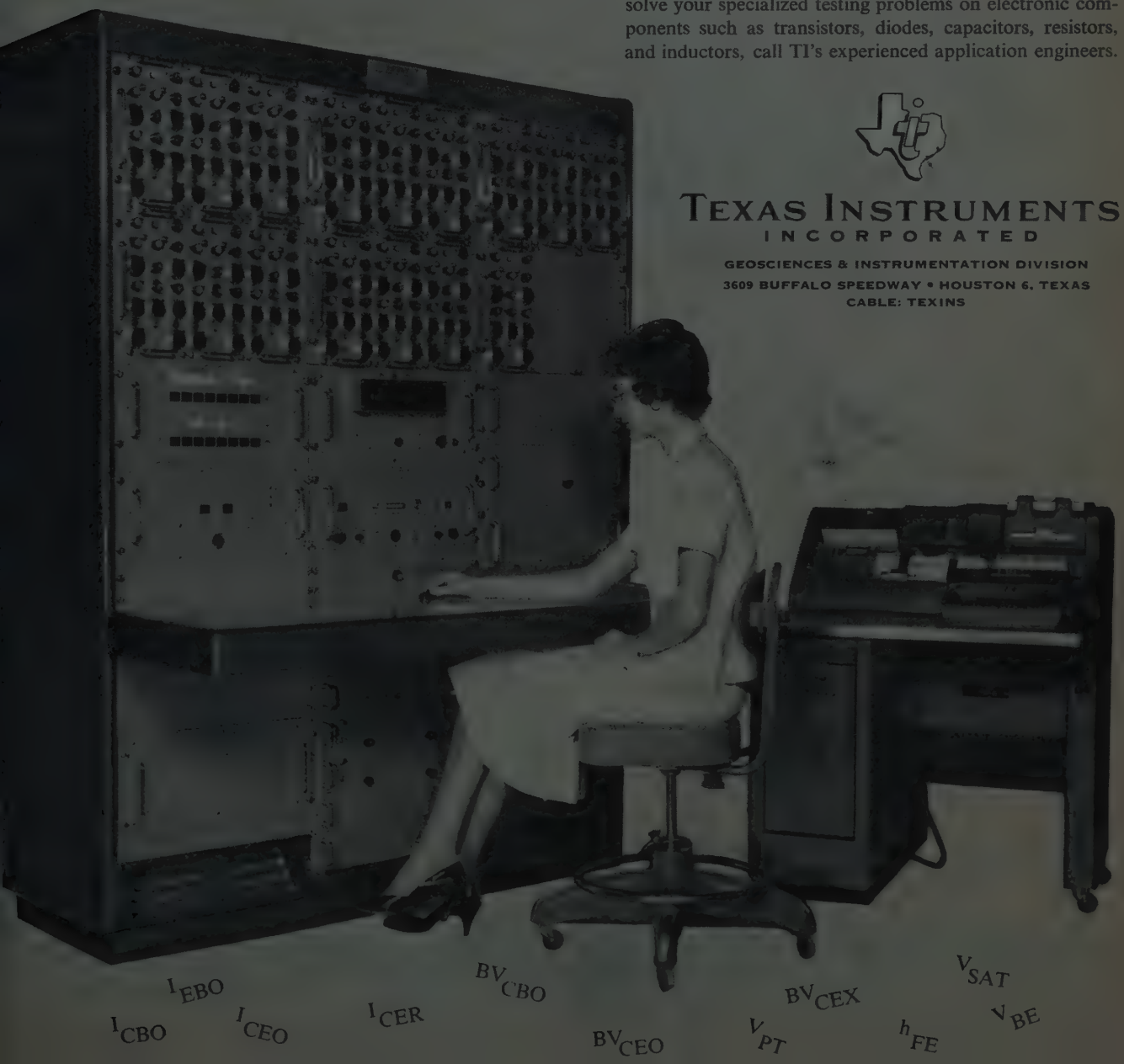
This new automatic testing-recording system offers you greater speed, more consistent accuracy, and lower unit testing costs than are obtainable by any hand testing means. Whether your requirements are Engineering Studies, Quality Assurance, Quality Control or Reliability Testing of semiconductor devices, SMART will add greatly to the efficiency of your operation.

The standard SMART machine enables you to measure up to 16 different d-c parameters of a transistor or other semiconductor device and record these data within 12 seconds. A minimum time of .5-second is required to test each parameter and an additional .2-second records the intelligence on an IBM 526 Summary Punch or other digital recording device. Using all 16 parameters, of course, 300 transistors may be tested per hour; however, fewer parameters would be desired on most testing runs and upwards of 500 semiconductors/hour could be handled easily.

Sixteen programming modules permit you to skip, hold, or delay individual tests as well as control the level of biasing supplies. You may record actual parameter values or set the machine for rejection limits only. Overall system accuracy is 1% of full scale readout.

The highly versatile SMART, with auxiliary consoles, may also be used for small signal h parameters; pulse, high frequency and power testing; and with environmental equipment in many types of factorial analyses. Also, the system may utilize scanning units for production runs, thus adding another high speed automatic feature.

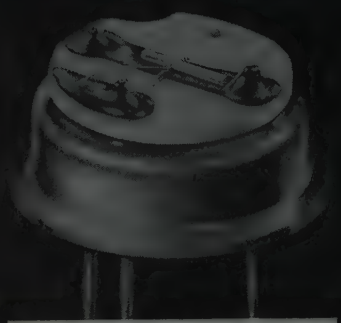
Request Bulletin A-701 for additional information. To solve your specialized testing problems on electronic components such as transistors, diodes, capacitors, resistors, and inductors, call TI's experienced application engineers.



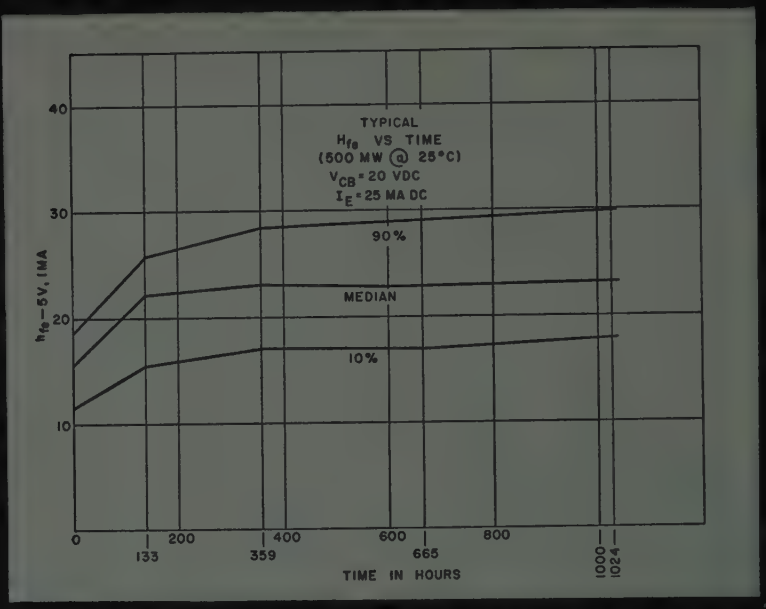
TEXAS INSTRUMENTS
INCORPORATED

GEOSCIENCES & INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS
CABLE: TEXINS

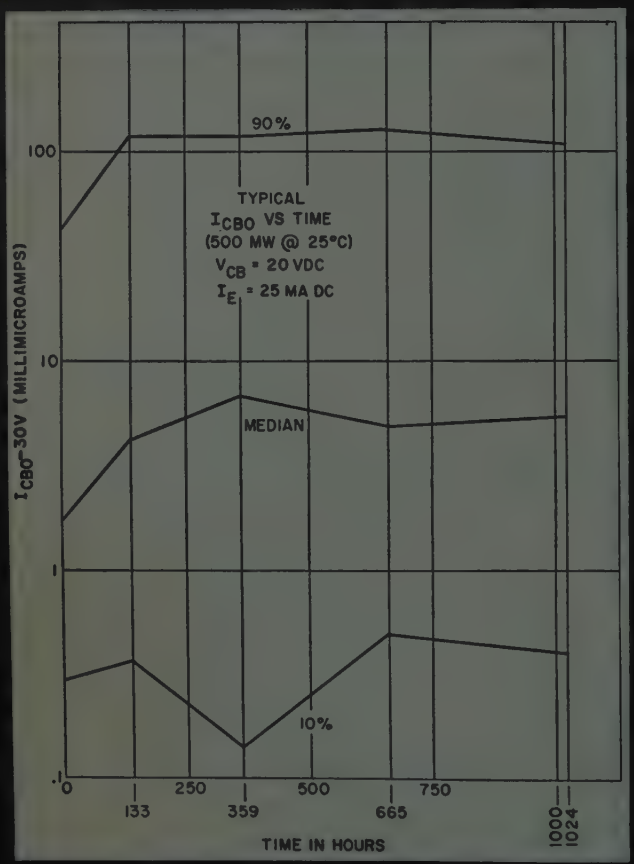
New silicon triodes dissipate

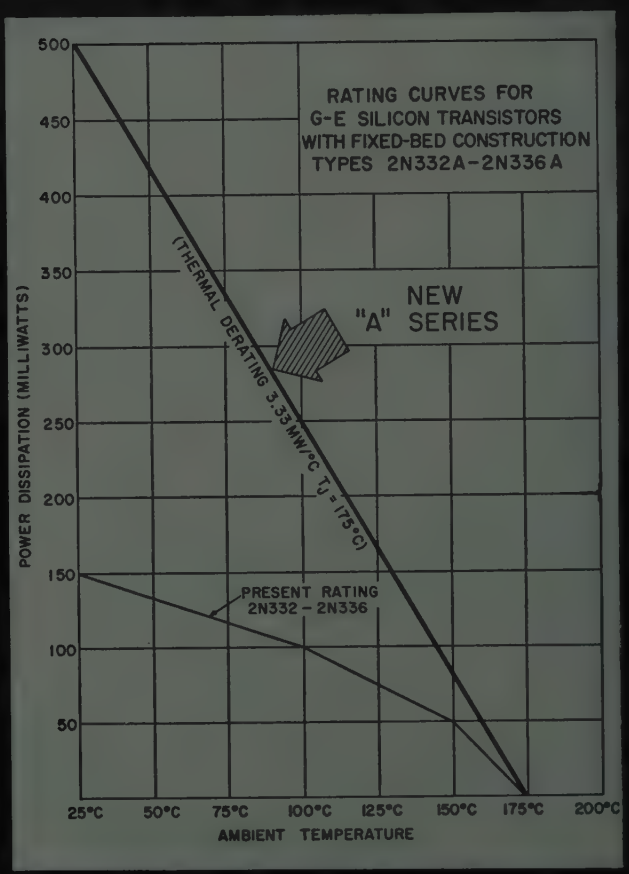


Greatly magnified photo of silicon transistor showing Fixed Bed Construction. All parts are firmly fastened, with no suspended parts except wire lead. Transistor reacts as a solid block in resisting shock and vibration. Power dissipation is inherently higher.



Power dissipation of the 2N332A-through-2N336A silicon transistors (see chart below) ranges from 500 mw at 25°C to 83 mw at 150°C without heat sink. Note also (see chart below, left) the extremely low I_{CBO} throughout 1000 hours of testing. Nearly 90% of units fall within 100 mμa. Beta spread (chart above) is stable out to 1000 hours.





500 mw without heat sink at 25°C

FIXED BED MOUNTED TRANSISTORS 2N332A-through-2N336A ALSO FEATURE:

4 VOLT V_{EB} . . . GUARANTEED 45 VOLT V_{CE} . . . .005 μa MAX. I_{CBO}

AT 25°C AND 30 VOLTS . . . PHYSICAL AND ELECTRICAL STABILITY

The 2N332A-through-2N336A line of silicon NPN triodes is a new series of amplifier and switching transistors capable of much higher performance than ever before achieved.

Collector dissipation without heat sink is 500 mw at 25°C . . . 83 mw at 150°C. Since reliability is related to junction temperature, even those designs which do not require maximum-rated power may be enhanced greatly by this device series because of the wide safety-factor potential provided.

FOUR OTHER ADVANTAGES—Collector-to-emitter voltage is guaranteed at 45 volts. Collector leakage current is a maximum of 500 mμa at 30 volts and 25°C. Collector-to-emitter leakage current is 60 μa at 150°C. Minimum cutoff frequency is 2.5 mc, typical f_{ab} is 10 to 15 mc.

FIXED BED MOUNTING—Fixed Bed Mounting is an exclusive G-E construction technique which contributes to the extreme stability obtained by this series of transistors. Storage and operating tests have resulted in a performance rate of better than 99.2% after 1000 hours.

Besides the demonstrated electrical characteristics, General Electric's silicon transistors can absorb physical punishment far beyond normal specifications. All parts are solidly fixed together and react as a solid block in resisting shock and vibration. Test units have been fired from a shotgun, struck with a golf club and rattled freely in an auto hubcap for 700 miles—and worked afterward.

IMMEDIATELY AVAILABLE—All types are available now from warehouse stock. Call your General Electric Semiconductor Sales Representative for complete details on the "hot" transistor line that operates the coolest. General Electric Company, Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

TYPE 2N333-THROUGH-2N335 SILICON TRANSISTORS MEET MIL-T-19500/37A SPEC.

Designing to the new MIL-T-19500/37A Spec? General Electric types 2N333, 2N334 and 2N335 can be supplied from warehouse stock to meet this specification.

SPECIFICATIONS

lute Maximum Ratings (25°C)

ltages		
Collector to Base	V_{CB}	45 volts
Collector to Emitter	V_{CE}	45 volts
Emitter to Base	V_{EB}	4 volts
rrent		
Collector	I_C	25 ma
wer		
Collector Dissipation RMS	P_c	500 mw @ 25°C (Free Air)
	P_c	83 mw @ 150°C (Free Air)
mperature		
Storage	T_{STG}	−65 to 200°C
Operating Junction	T_J	−65 to 175°C

rical Characteristics (Typical at 25°C)

C Characteristics		2N332A	2N333A	2N334A	2N335A	2N336A	
rward Current Transfer Ratio (low current) (I_C=1 ma, V_{CE}=5 V)	h_{FE}	16	27	36	45	75	
turation Voltage (I_B=1 ma, I_C=5 ma)	V_{CE} (Sat)	.5	.45	.42	.4	.4	volts
toff Characteristics							
llector Current (V_{CB}=30 V; I_E=0; T_A =25°C)	I_{CBO}	1	1	1	1	1	mμa
llector Emitter Current (V_{CE}=30 V; I_B=0; T_A =150°C)	I_{CEO}	60	60	60	60	60	μa
w Frequency Characteristics (V_{CB}=5 V; I_E= −1 ma; f=1000 cps)							
rward Current Transfer Ratio	h_{fe}	16	30	38	52	95	
put Impedance	h_{ie}	750	1300	1700	2000	3700	ohms
tput Admittance	h_{oe}	3.5	5.0	6.0	7.0	9.0	μmhos
tput Admittance	h_{ob}	.25	.2	.18	.15	.13	μmhos
gh Frequency Characteristics (Common Base) (V_{CB}=5 V; I_E= −1 ma)							
tput Capacity (f=1 mc)	C_{ob}	7	7	7	7	7	μμf
toff Frequency	f_{ab}	10	11	12	13	15	mc
wer Gain (common emitter) (V_{CE}=20 V; I_E= −2 ma; f=5 mc)	G_e	11	11	12	12	12	dB

GENERAL ELECTRIC

PRECISE MicroMatch®
COAXIAL TUNERS
TUNE TO
VSWR 1.000 200-4000 MCS.

MAKES YOUR LOAD A REFLECTIONLESS TERMINATION

DESIGNED FOR USE whenever extremely accurate RF power terminations are required. This laboratory type Coaxial Tuner will tune out discontinuities of 2 to 1 in coaxial transmission line systems or adjust residual VSWR to 1.000 of loads, antennas, etc. May also be used to introduce a mismatch into an otherwise matched system.

M. C. JONES COAXIAL TUNER is designed for extreme ease of operation, with no difficult laboratory techniques involved. Reduces tuning time to a matter of seconds. Graduations on carriage and probe permit resetting whenever reusing the same termination.

SPECIFICATIONS

Impedance	50.0 ohms
Frequency Range	Model 151N 200-1000 Mcs. Model 152N 500-4000 Mcs.
RF Connectors	EIA 7/8" 50.0 ohm Flange plus adapters to N female connector
Power Rating	100 watts
Range of Correction	VSWR as high as 2 may be reduced to a value of 1.000

FOR MORE INFORMATION ON TUNERS, DIRECTIONAL COUPLERS, R. F. LOADS, Etc., PLEASE WRITE TO:

M.C. Jones

M. C. JONES ELECTRONICS CO., INC.
185 N. MAIN STREET, BRISTOL, CONN.
SUBSIDIARY OF
Bendix AVIATION CORPORATION

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

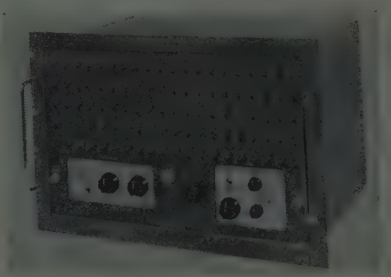
(Continued from page 104A)

five times as much power with only temporary electrical characteristic degradation.

Copies are available from **Polytechnic Research & Development Co., Inc.,** 202 Tillary St., Brooklyn 1, N. Y.

Pulse Pattern Generator

Designed for versatility in electronic equipment testing both for military and industrial applications, by **Data Products Co., Inc.,** 7320 Westmore Rd., Rockville, Md., the transistorized Pulse Pattern Generator provides a simulated and flexible time division pulse pattern.



The test set provides a single dependable unit for testing both slow and high-speed electronic systems such as: guidance systems, computers, communications systems, data transmission systems, and telementary systems.

This generator performs well on electronic equipment employing a time division multiplex principle, because of the following operational characteristics:

Generates a pulse pattern any length from 1 to 100 pulses.

Pulse rate continuously variable from 10 to 100,000 pps using internal oscillator.

Can be driven by external oscillator at a pulse rate as low as desired and up to 100,000 pulse per second.

State of each pulse in a pulse sequence can be controlled independently from the front panel. Each pulse assumes a mark or space condition depending on the position of the switch representing that pulse. Test set has 100 switches which represent 100 possible pulse positions.

Output level for the mark (one) condition is continuously variable from zero to +10 volts. Output for the space (zero) condition is continuously variable from zero to 10 volts.

Eight microsecond cycle pulse output (occurring at beginning of each pulse sequence) is provided.

Two microsecond clock pulse output (occurring every pulse time) is provided.

Provides up to ±30% pulse width bias.

Operates from a nominal 117 volts, 50–400-cps, power system.

One microsecond rise and fall time.

Tone keyer optionally available.

Complete technical information can be obtained by writing to the firm.

(Continued on page 114A)

WHY is WESTREX PLEXITEL the most advanced single sideband radio communications system?

Single sideband radio transmission systems have been in use since the early 1930's. At Westrex we were among the pioneers with these systems and, in fact, Westrex has engineered and installed in foreign countries the majority of the commercial overseas point-to-point single sideband radio telephone circuits in use today.

The advantages of SSB are obvious. With one sideband suppressed, power thus saved is available for the remaining sideband, and tube load is much reduced. SSB transmission conserves space in the frequency spectrum, requires only a fraction of the power of double sideband, and provides a gain of approximately 9 db in signal-to-noise ratio.

Systems design through the years has evolved into very compact units. Today the Westrex Plexitel transmitter and receiver are each contained in a cabinet 84 inches high, 22¼ inches wide, and 17 inches deep. A lot of capability is packed into that space.

The transmitter provides a peak power output of 500 watts on any of ten predetermined crystal-controlled frequencies in the range of 3-30 megacycles. It is available in a number of combinations which permit the transmission of 1, 2, 3, or 4 separate telephone channels or each of these 3 kc voice channels may be selected to transmit up to 16 channels of radio printer intelligence, giving a total of 64 teleprinter channels. Facilities for channel grouping are an optional feature and may be added as future requirements dictate. Various linear amplifier combinations up to 10 kw may be used with the 8A transmitter.

The channel arrangement of the Westrex receiver in the Plexitel System is identical with that of the transmitter. Each 6 kc sideband may be used as a whole or subdivided into multi-message channels by appropriate optional equipment. As many as ten crystal-controlled frequencies may be pre-set for rapid selection by one manually operated knob. Remote control equipment is available which will activate or deactivate the receiver and select any one of the ten channels.

Both transmitter and receiver are designed to operate at altitudes up to 10,000 feet and under severe climatic conditions. Frequency stability of the Plexitel System is in the order of ±3 parts in ten million per day. No other SSB system is so conveniently adaptable to simple point-to-point, aviation ground, or marine applications; or to the more complex point-to-point radio system applications.

The 8A transmitter or 52A receiver may be used with any SSB system having similar characteristics and may also be operated on AM or DSB.

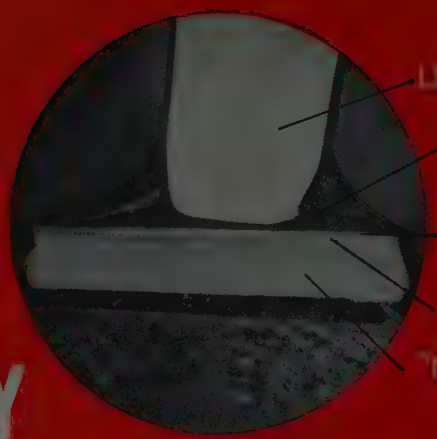
The many high quality refinements of construction are listed in our Plexitel brochure. We will send you your copy by return mail. Westrex Corporation, 111 Eighth Avenue, New York 11, N.Y.

Westrex Corporation
A DIVISION OF LITTON INDUSTRIES

DIFFUSED-JUNCTION UNIFORMITY

assures reliability, long life of

RCA SILICON RECTIFIERS



This photomicrograph shows the exceptional junction flatness across the entire pellet that is typical of silicon rectifiers produced by the RCA diffusion process. This junction flatness is achieved by slow-rate diffusion, which permits precise control of diffusion depth and junction gradient. Results—uniform current density throughout the silicon, with consequent freedom from "hot spots"; improved electrical characteristics in both forward and reverse directions; and exceptional uniformity from unit to unit.

Advanced manufacturing techniques and extensive quality-control procedures are your assurance of reliability and long life when you specify RCA Silicon Rectifiers. *Every RCA Silicon Rectifier* you receive has been subjected to a 24-hour seal test under pressures in excess of 5 atmospheres, and has been stabilized by repeated thermal cycling over the full operating-temperature range before final electrical testing. *Every RCA Silicon Rectifier* you receive has also been subjected to the following extra tests to insure dependable performance under extreme conditions: reverse (leakage) current at 25°C; forward characteristics at 25°C; high-temperature dynamic reverse (leakage) current test at full load current and maximum rated voltage. In addition, samples from every production lot of RCA Silicon Rectifiers are subjected to life tests under maximum rated conditions of temperature, current, and voltage to provide further assurance of RCA's high standards of quality.

7 Types for INDUSTRIAL and MILITARY Power Supplies

Maximum Ratings, Absolute-Maximum Values: For supply frequency of 60 cycles and with resistive or inductive load

RCA Type	Peak Inverse Volts	DC Forward Ma at Ambient Temperature of 50°C	CHARACTERISTICS	
			at Ambient Temperature of 25°C	at Ambient Temperature of 150°C
			Maximum Reverse Current (DC) at maximum peak inverse voltage (μa)	Maximum Reverse Current (averaged over one complete cycle) at maximum peak inverse voltage (μa)
1N536	50	750	5	400
1N537	100	750	5	400
1N538	200	750	5	300
1N539	300	750	5	300
1N540	400	750	5	300
1N1095	500	750	5	300
1N547	600	750	5	350
6 Types for MAGNETIC-AMPLIFIER Applications requiring exceptionally low leakage current				
1N440-B	100	750	0.3	100
1N441-B	200	750	0.75	100
1N442-B	300	750	1.0	200
1N443-B	400	750	1.5	200
1N444-B	500	650	1.75	200
1N445-B	600	650	2.0	200

Contact the RCA Field Office nearest you for information on types for your specific applications. For technical data see the new RCA HB-10 SEMICONDUCTOR PRODUCTS HANDBOOK, or write RCA Commercial Engineering, Section L-35-NN, Somerville, N.J

EAST:
744 Broad Street
Newark 2, New Jersey
HUmboldt 5-3900

EAST CENTRAL:
714 New Center Bldg.
Detroit 2, Mich.
TRinity 5-5600

WEST:
6355 E. Washington Blvd.
Los Angeles 22, Calif.
RAymond 3-8361

NORTHEAST:
64 "A" Street
Needham Heights 94, Mass.
Hillcrest 4-7200

GOVERNMENT:
224 N. Wilkinson Street
Dayton 2, Ohio
BAldwin 6-2366

1625 "K" Street, N. W.
Washington 6, D. C.
District 7-1260

CENTRAL: Suite 1154, Merchandise Mart Plaza, Chicago 54, Illinois. WHitehall 4-2900

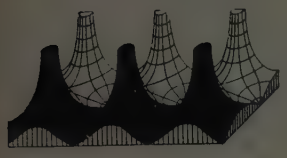
ALSO AVAILABLE AT YOUR LOCAL RCA SEMICONDUCTOR DISTRIBUTOR

RADIO CORPORATION OF AMERICA
SEMICONDUCTOR AND MATERIALS DIVISION • SOMERVILLE, N. J.

December, 1959
Vol. 47 No. 12

Proceedings of the IRE

Poles and Zeros



The International Scene. In connection with the IRE Canadian Region Convention and Exposition in Toronto in October, the Board of Directors met for the first time outside the bounds of the United States, again demonstrating that the IRE is international in scope. To further carry out this theme, the Board occupied an extra day in discussion of the IRE position on international science and electronic questions.

The duties of the Senior Past President, in connection with Sections outside North America, were reiterated, and a resolution offering the services of the IRE in radio and electronic professional matters wherever located, was passed. At the same time it was emphasized by the Board that the IRE had no intent to displace any activities undertaken on a national basis.

The Board also established the policy of inviting to its meetings the Vice-President who resides outside North America. It is hoped, thereby, to increase the knowledge of IRE abroad, as well as to aid the Board in its handling of international questions. Such visits have occurred in the past, our most recent visitors being Dr. Yasujiro Niwa of Japan, M. J. H. Ponte of France, Dr. Franz Tank of Switzerland, and Herre Rinia of the Netherlands.

In the past, IRE has cooperated with or appointed representatives on many international scientific bodies. Director Berkner, who has served as director of the U.S. program for the I.G.Y., and in other international activities, gave the Board a briefing on the operating objectives and relationships between the numerous international scientific bodies such as ICSU (International Council of Scientific Unions), URSI (International Scientific Radio Union), CCIR (International Radio Consultative Committee), ITU (International Telecommunications Union), IEC (International Electrotechnical Commission), and IAU (International Astronautical Union). Because of similar or complementary interests, the IRE has particularly close contact with URSI and IEC. Director Berkner's discussion will ultimately appear in the PROCEEDINGS, since it was felt that a knowledge of the international scientific scene would be of interest to all members.

It was also pointed out that India and Japan had in recent years taken steps to change to the metric system of weights and measures, and that the U.S.A., Canada, and Great Britain might soon remain the only domains still measured by King Canute's pedal extremity. In view of studies by the National Bureau of Standards, an *ad hoc* committee will be established to study the technical implications and practical problems which would arise in electronics through the possible adoption of the metric system of weights and measures in the United States.

The Canadian Region Convention Committee set a high mark for friendliness and hospitality. The Region is certainly favored in having available one of the finest hotels in the British empire as headquarters, and ample and pleasant exposition space. It was a great pleasure to visit an exposition which had aisles between the exhibits, instead of the usual cowpaths in the Casbah.

Teaching Teachers. Last month we mentioned that teaching staffs in engineering colleges were short. We are now advised that the shortage is in the neighborhood of 13 per cent, although much greater if less than desired competence is allowed for. Certainly many are being found to stand in front of classes who do not yet measure up to what the engineering profession would like, or has a right to expect.

The teaching fraternity is taking positive steps to attract and develop new teachers. The American Society for Engineering Education of Urbana, Ill., has for several years had an active Committee for the Development of Engineering Faculties, logically referred to as C.D.E.F.

An engineering teacher becomes such only after exposure to the academic atmosphere of learning in residence on a campus, and acquisition of several degrees beyong the bachelor's level. Because of this C.D.E.F. is beginning by showing qualified seniors the advantages of graduate work *in residence*, as preparation for teaching, or if that fails to appeal, for a fuller professional life. The in residence emphasis is important, because only in this way does the student gain unhampered time for graduate study, plus the opportunity to experiment with teaching as a life work.

The C.D.E.F. group has prepared a helpful booklet "Teaching Tomorrow's Engineers." The possibilities opened to a young teacher by this booklet make one wish he were starting over again, complete with all modern advantages.

The National Science Foundation has also aided the teaching cause through grants allowing young teachers to complete their degree programs free of financial worry, or as a "capitalist," as one young faculty man put it.

More and More. Most Professional Groups have been publishing their Transactions on a quarterly basis over the past eight years. As an historical note, we here record that, because of increasing quantities of material, the Transactions of the Professional Group on Antennas and Propagation, and of the Professional Group on Microwave Theory and Techniques will in 1960 shift to a bimonthly basis.

This is an important milestone in the growth of the Professional Groups. Conceived eleven years ago, and only in their eighth year of publication, they are now publishing at an annual rate of more than 6000 pages. Additional indication of the value of the Groups in disseminating technical information is their enthusiasm in sponsoring symposia to serve their members across the country.

Will we have monthlies by 1965?—J.D.R.

Gordon K. Teal

Director, 1959

Gordon K. Teal (SM'53–F'56), assistant vice-president and director of research of Texas Instruments Inc., was born in Dallas, Texas, on January 10, 1907. After receiving the B.A. degree from Baylor University in 1927, he went to Brown University as a Marston Scholar and during the two succeeding years was a University Fellow and a Metcalf Fellow. Brown awarded him the M.S. degree in 1928 and a Doctorate in 1931. From 1933 to 1935 he was research associate at Columbia University where he carried on a research program concerned with heavy hydrogen.

He joined Bell Telephone Laboratories in 1930 and over a period of 22 years with BTL conducted research and development in numerous areas. These included studies in electricity, secondary emission, photoconductance, electron multipliers, silicon carbide varistors, germanium and silicon rectifiers, microwave attenuators, borocarbon resistors, germanium and silicon single-crystals, and transistors. He has over 46 patents granted or pending as a result of his research in these fields.

He joined Texas Instruments in 1953 as head of the Materials and Components Research Department, with primary responsibility for semiconductor research. Since 1955 he has been in charge of TI's Central Research Laboratories, where research is carried on in the broad areas of chemistry, physics, electronic devices, as well as systems and earth sciences.

His IRE activities have included service on the Editorial Review Committee from 1955–1959, and on the Editorial Board from 1958–1959. He has served as Chairman of the Sections Publications Committee since 1957, his present term extending to 1960. He was secretary of the Dallas-Fort Worth Section in 1953–1954 and vice-chairman in 1955–1956, becoming chairman of the Dallas Section in 1956–1957. He is Chairman of the Technical Program Committee for the 1960 IRE Convention.

Dr. Teal holds membership in the American Chemical Society, the American Physical Society, the Electrochemical Society, and Sigma Xi. He is an honorary member of Sigma Pi Sigma and is a fellow of the American Association for the Advancement of Science. He is the 1959–1960 Executive Vice-President for the Texas Academy of Sciences. He is a member of the American Management Association, serves on the Working Group on Electronic Materials of the Advisory Group on Electronic Parts, and is the representative for Texas Instruments on the Industrial Research Institute.

Scanning the Issue

Poisson, Shannon, and the Radio Amateur (Costas, p. 2058)—It should be mentioned at the outset that this paper is by no means addressed solely to radio amateurs nor confined to amateur radio. It deals rather with a topic of much broader import, namely, the efficient usage of congested communication channels. Frequency spectrum conservation has become one of the major post-war crusades of the radio engineering fraternity. Much attention has been devoted to techniques for reducing the bandwidth of communication systems, to the point where bandwidth conservation is now generally accepted as being synonymous with spectrum conservation. It may therefore come as somewhat of a shock to some to find someone proposing that in some situations a more efficient system can be achieved by *increasing* the bandwidth. The author is specifically concerned with the relative merits of single sideband versus double sideband systems in situations where a large number of transmitters operate intermittently in an uncontrolled fashion within the same portion of the radio band. These conditions are common not only in amateur radio but, perhaps more importantly, in military communications. The author reminds us that the broader bandwidth signals of DSB increase the ability of the receiving system to discriminate between the desired signal and interference. This results in significant improvements in operational reliability and in channel capacity. In military communications, it also makes the system decidedly less susceptible to jamming. Some of the author's contentions will probably arouse controversy from some readers, principally because they seem to contradict commonly held notions of systems design and frequency assignment practice. In calling attention to the advantages of broad-band systems over narrow-band systems, the author has presented some novel and stimulating ideas regarding the congested band problem which will be of considerable interest to communication system designers and users and to information theorists.

Electronic Scanning System for Infrared Imaging (Lasser, Cholet and Emmons, p. 2069)—Close on the heels of the Infrared Issue of the PROCEEDINGS comes a totally new technique for converting infrared images into visible ones. Readers of the September issue will remember that mechanical scanning systems have undergone many years of development and are used in a majority of applications at present. Electronic systems, on the other hand, although presently limited in system detectivity, offer great promise for the future because they are inherently faster and less cumbersome. In the latter category, two principal types have been developed to date: 1) photoemissive image tubes, in which the infrared image radiation is converted into electron emission which is picked up either by a phosphor screen or by an image orthicon television camera tube, and 2) photoconductive tubes, in which the infrared image is converted into variations in surface charge which are sensed by a scanning electron beam. The electronics and optics of scanning and display systems have already been developed to a high degree by television engineers. The application of these techniques to infrared imaging depends primarily on the development of photosensitive transducer materials of good sensitivity and spectral response. In the present paper, the authors have developed a new type of tube in which the crucial element is a semiconducting window made of silicon. The window will normally pass infrared radiation. However, if the window is subjected to electron bombardment, the bombarded area will become opaque. Thus by focussing an infrared image on the window and scanning it with an electron beam, a moving opaque spot is produced which subtracts a small variable amount of energy as the image passes through the window and on to an infrared detector. The energy variations are converted by the detector into a video signal, which is then fed to a television-type monitor for display. This novel development will interest many workers in the television and semiconductor fields, as well as those concerned with infrared and military systems.

Frequency Multiplication with Nonlinear Capacitors—A Circuit Analysis (Leeson and Weinreb, p. 2076)—There is widespread interest today in circuits with varying parameters, especially in connection with parametric amplifiers and harmonic generators. With respect to the latter, earlier PROCEEDINGS papers have shown that theoretically a relatively lossless nonlinear reactance is far more efficient than an ideal diode (nonlinear resistance) in converting power at the fundamental frequency into power at a harmonic. Meanwhile, the recent development of high-Q semiconductor nonlinear capacitors has offered a very promising practical way of obtaining a nonlinear reactance that is relatively lossless. The present paper derives basic circuit equations and impedance relationships which enable a designer to specify the conditions which will give him optimum power capabilities and efficiency for any given circuit and harmonic. The analysis, incidentally, is also applicable to frequency dividers, and to multipliers employing nonlinear inductance.

Operating Characteristics of an Ammonia Beam Maser (Barnes, p. 2085)—The first operating maser was constructed by Townes and his associates at Columbia University in 1954. Shortly thereafter, workers at Stanford constructed the two masers on which the measurements described in this paper were made. Masers of this type have found important use as ultra-stable frequency standards. To date, long term stabilities of better than one part in 10^{11} and short term stabilities of 2 parts in 10^{12} have been achieved. This paper investigates the kinds of side effects which must be overcome or minimized to obtain even greater accuracies, not only in frequency stability, but also in reproducibility of a selected frequency. It presents what is probably the most complete description of operating characteristics and comparison of theory and experiment that has yet been published.

Coaxial Resonators with Helical Inner Conductor (Macalpine and Schildknecht, p. 2099)—The resonators described in this paper are especially noteworthy because they provide high Q's over a wide frequency range—from a few megacycles to over 1000 mc—and are of a very practical size. For example, one of these helical resonators designed for use at 10 mc need be only 8 inches long, whereas a conventional coaxial resonator would require 25 feet. This paper gives exact details for constructing helical resonators. The designs and performance characteristics are given in the clear and concise form of handbook information. This paper will be of wide interest to workers in many electronic fields. It represents very fine reduction of known relations to a highly practical and usable form.

Digital Rate Synthesis for Frequency Measurement and Control (Rey, p. 3006)—This paper describes a method of frequency measurement and control in which conventional techniques are replaced by pulse techniques. In essence, the method consists of representing the signal whose frequency is to be measured or controlled in the form of a pulse train and comparing its pulse rate with that of a controllable variable-rate pulse reference source. A detector measures the difference rate and produces an output which indicates the magnitude and sign of the difference. In an automatic frequency control circuit, the rate difference signal would be used to drive a tuning motor to reduce the tuning error toward zero. At present the technique is of special interest in the fields of computing systems and motor speed control. However, frequency measurement and control is of such basic importance to so many fields that new ideas are certain to find a broad and receptive audience.

Scanning the Transactions appears on p. 2123.

Poisson, Shannon, and the Radio Amateur*

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Summary—Congested band operation as found in the amateur service presents an interesting problem in analysis which can only be solved by statistical methods. Consideration is given to the relative merits of two currently popular modulation techniques, SSB and DSB. It is found that in spite of the bandwidth economy of SSB this system can claim no over-all advantage with respect to DSB for this service. It is further shown that there are definite advantages to the use of very broadband techniques in the amateur service.

The results obtained from the analysis of the radio amateur service are significant, for they challenge the intuitively obvious and universally accepted thesis that congestion in the radio frequency spectrum can only be relieved by the use of progressively smaller transmission bandwidths obtained by appropriate coding and modulation techniques. In order to study the general problem of spectrum utilization, some basic results of information theory are required Some of the significant work of Shannon is reviewed with special emphasis on his channel capacity formula. It is shown that this famous formula, in spite of its deep philosophical significance, cannot be used meaningfully in the analysis and design of practical, present day communications systems. A more suitable channel capacity formula is derived for the practical case.

The analytical results thus obtained are used to show that broadband techniques have definite merit for both civil and military applications. Furthermore, such techniques will result in far more efficient spectrum utilization in many applications than any practical narrow-band, frequency-channelized approach. Thus broad-band techniques can, in many cases, increase the number of available "channels." With regard to military communications it is shown that the ability of a communication system to resist jamming varies in direct proportion to the transmission bandwidth for a given data rate. Thus narrow-band techniques lead progressively to more expensive communications systems and less expensive jammers. It is concluded that in the military field broad-band techniques are not only desirable but also often mandatory.

I. Introduction

MOST common usage of the radio frequency spectrum involves operation at specified frequencies as assigned by the appropriate regulatory agencies in the various countries. In contrast, the radio amateur service is assigned various bands of frequencies and properly licensed stations are permitted to operate at any frequency within these bands. This freedom of choice of frequency is necessitated by the obviously impossible administrative problem of assigning specific frequencies to specific stations and, furthermore, the available bandwidths fall short by several orders of magnitude of providing exclusive channels to each authorized station. Thus, as one might suspect, the situation in the amateur bands is a chaotic one in terms of mutual interference. There is very little tendency to "channelize" for several reasons. The crowded conditions normally leave no empty spaces in frequency so that a station starting operation has no choice but to transmit "in between" two strong stations or on top of a weaker station. Furthermore, at the higher HF frequencies, the ionospheric "skip" makes it impossible to choose a good operating frequency by listening, since the signal situation will be radically different between two points spaced many miles apart. Thus, the very nature of the amateur service would lead one to expect that any meaningful analysis of this problem must be based on a statistical approach.

A mathematical study of amateur radio communications can be of use in other important areas. Consider, for example, military communications where allocation of frequencies cannot possibly prevent interference due to the use of the same frequencies by the opposing forces. It is not hard to imagine that under such conditions each operator will shift frequency and take other appropriate action in order to get his message through. Thus, in a combat area we might well expect to find the very same chaos in the communications services that we observe in the amateur bands today. Certainly in such situations interference cannot be eliminated by allocation; interference will exist and we must simply learn to live with it. We are not speaking here of intentional jamming but rather of the casual interference which is inevitable when two opposing military forces (which today depend heavily on radio) attempt to operate independently and use the same electromagnetic spectrum. The problem of intentional jamming will be treated in detail in Section VI.

In the analysis of the radio amateur problem which follows, three modes of operation are compared. It is first assumed that all stations employ suppressed-carrier single-sideband (SSB). Then exclusive use of suppressed-carrier AM (DSB) is assumed. Finally, a frequency diversity system is examined in which each station transmits a large number of identical signals at randomly selected frequencies in the band. Intuitively we might suspect that SSB would be superior to DSB because of the two-to-one difference in signal bandwidths. The frequency diversity system is intuitively ridiculous because it apparently "wastes" bandwidth rather indiscriminantly. As we shall see, intuition is a poor guide in these matters. The feeling that we should always try to "conserve bandwidth" is no doubt caused by an environment in which it has been standard practice to share the RF spectrum on a frequency basis. Our emotions do not alter the fact that bandwidth is but one dimension of a multidimensional situation.

* Original manuscript received by the IRE, April 21, 1959; revised manuscript received, June 13, 1959.
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II. Congested Band Analysis

SSB Case

We shall first consider the case of exclusive use of SSB. The spectral situation is shown in Fig. 1 as it might

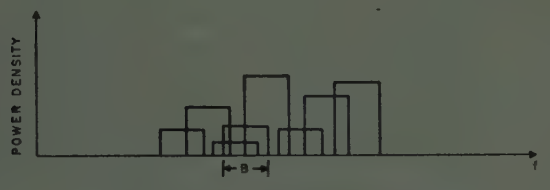

Fig. 1—Power density spectra—SSB case.

appear to a particular receiver. Each signal occupies a bandwidth B (equal to the baseband bandwidth for SSB), has a location in frequency independent of all other signal locations, and has an amplitude of power density independent of all other signal amplitudes. The signal amplitudes will have a probability distribution which will be specified at a later time. While the frequency locations of the various signals are distributed at random, it can be said that, on the average, there are a given number of signals per given unit of bandwidth. Thus, we may specify the density of loading of the band by a quantity k which represents the average number of signals per unit bandwidth. It happens that we shall need to know the probability of having a given number of signals ν falling in a bandwidth B. This, of course, is given for the conditions specified by the celebrated distribution of Poisson as

$$P(\nu, B) = \frac{(kB)^\nu}{\nu!} e^{-kB}, \tag{1}$$

where $P(\nu, B)$ is the probability of having ν signals in the bandwidth B if there are k signals per unit bandwidth on the average.

The choice of the distribution function for the signal power densities is somewhat arbitrary and, as far as the final results are concerned, apparently not particularly critical. It is physically reasonable and mathematically convenient to choose the chi-squared distribution[1]

$$p_\nu(x) = \frac{x^{\nu/2-1}e^{-x/2}}{2^{\nu/2}\Gamma(\nu/2)} \qquad (x \geq 0), \tag{2}$$

where $p_\nu(x)$ is the probability density function of the spectral amplitude which results from the summation of ν independent signals. For $\nu = 1$ the distribution has a mean of unity. This specifies that the average signal strength at the receiver is unity which results in no loss of generality for this application.

For convenience only, we shall assume that we are receiving a signal of average strength and want to find the probability that the Signal-to-Noise Ratio at the receiver output will equal or exceed a specified value. For SSB operation, the SNR at RF is the same as the SNR at the receiver output. We shall estimate the effective noise level at the receiver input by noting the interference level at the center of the pass band. We shall now determine the probability that the interference level will be less than or equal to J, which means that the SNR at the receiver output will be equal to or greater than $1/J$, since the desired signal is assumed to be of average strength of unity. Let $P_{SSB}(\text{SNR} \geq 1/J)$ be this probability. Then

$$P_{SSB}(\text{SNR} \geq 1/J) = P(0, B) + P(1, B) \int_0^J p_1(x)dx + P(2, B) \int_0^J p_2(x)dx + P(3, B) \int_0^J p_3(x)dx + \cdots, \tag{3}$$

which states that the event will occur if there are no signals in B, if there is one signal in B with amplitude less than J, if there are two signals in B the sum of whose amplitudes is less than J, etc. It should be clear that if an interfering signal is to contribute to the measurement of interference, its lowest frequency must fall somewhere within a frequency band extending from the center of the pass band to B cycles below. It is to this event that the terms $P(\nu, B)$ in (3) refer. Substituting (1) and (2) into (3) one obtains

$$P_{SSB}(\text{SNR} \geq 1/J) = e^{-kB}\left[1 + \sum_{\nu=1}^{\infty} \frac{(kB)^\nu}{\nu!} \int_0^J \frac{x^{\nu/2-1}e^{-x/2}}{2^{\nu/2}\Gamma(\nu/2)}\, dx\right]. \tag{4}$$

Evaluation of (4) for a fixed J and variable k will give the probability of exceeding a certain receiver output SNR as a function of band loading. For example, for $J = 1$ the expression gives the probability of exceeding a 0-db SNR when receiving a signal of average strength, or of exceeding a +3-db SNR when receiving a signal of twice (power) average strength, etc. Fortunately, the integral function in (4) is tabulated[2] and the series converges rather rapidly, so that the numerical work involved in evaluating (4) is not too difficult.

DSB Case

As might be suspected, the analysis of the case involving exclusive use of DSB is quite similar to the SSB analysis. There are two important differences to be noted. First, since all transmitted signals have twice the baseband bandwidth it is to be expected for a given band loading there will be more interfering signals involved than in the case of SSB. In the DSB analysis then, we will be concerned with the probability of having ν interfering signals in a bandwidth $2B$, using the same estimate of effective receiver input noise level as before.

[1] H. Cramer, "Mathematical Methods of Statistics," Princeton University Press, Princeton, N. J., ch. 18, 1946.

[2] C. D. Hodgman, "Mathematical Tables," Chemical Rubber Publishing Co., Cleveland, Ohio, p. 257; 1946.

Thus the Poisson distribution $P(\nu, 2B)$ must be used in the equation equivalent to (3) for the DSB analysis. This represents a loss caused by increased transmission bandwidth; there is a compensating gain as will be seen. The second difference between the SSB and DSB analysis involves the relationship between the predetector and postdetector SNR's. In SSB these two ratios are the same. In DSB the postdetector SNR is 3 db better than the predetector value. This difference arises because of the coherent addition of upper and lower sideband components of the signal and incoherent addition of the corresponding interference components in the synchronous detector. Thus, for identical output SNR's the interference power density will be two times as great relative to desired signal density in DSB as compared to SSB. Consequently, in the equation equivalent to (3) the upper limit on all integrals must be changed from J to $2J$ in order that J have the same meaning in both cases.

When the two changes discussed above are made, the probability of exceeding an output SNR of $1/J$ for a desired signal of mean strength (unity) becomes

$$P_{DSB}(\text{SNR} \geq 1/J) = e^{-2kB}\left[1 + \sum_{\nu=1}^{\infty} \frac{(2kB)^{\nu}}{\nu!} \int_0^{2J} \frac{x^{\nu/2-1}e^{-x/2}}{2^{\nu/2}\Gamma(\nu/2)}\, dx\right]. \quad (5)$$

A comparison of (4) and (5) shows that the increased bandwidth of DSB has in some ways been detrimental ($2kB$ in place of kB in the Poisson distribution), and in other ways beneficial ($2J$ in place of J in the integral expression). As later calculations show, the increased bandwidth of DSB does not affect the relative congested band performance as compared to SSB in any significant manner. We might begin to suspect that the efficient use of broader bandwidths in a congested operating band is not necessarily a bad idea. The broader bandwidth signals will increase the tendency of frequency overlap and tend, in a sense, to cause more interference. This is obvious. *What is not so obvious is the fact that the increased bandwidth gives to the receiving system an increased ability to discriminate between the desired signal and the interference.* In order to investigate further the effects of increasing transmission bandwidth, a rather simple form of broad-band technique will now be analyzed.

Frequency Diversity Case

For this example we shall use the SSB mode of transmission (although the DSB mode would yield identical results), in a somewhat unusual manner. Each station will transmit not one but M (where M is a large number) identical signals at randomly chosen frequencies in the congested band. The receiver must know these frequency locations so that all M signals may be received, detected, and added coherently to produce the receiver output signal. With each station transmitting M identical signals, the interference spectrum amplitude will, with nearly unit probability, be very nearly equal to a constant value at all frequencies for sufficiently large M. This value may be determined quite easily by inspection.

Consider first the normal SSB situation without diversity. The received signals are distributed in amplitude of power density about a mean of unity. Thus, the average received power is B watts per station. Since there are k stations per cycle on the average, the mean interference power density will be kB watts per cycle. Going from one transmission to M transmissions per station (assuming the power of each station is now split evenly between the M signals) does not alter the value of the average interference power density. In the diversity case this *average* value will be very nearly the *actual* value of interference density level which will exist at all frequencies and at all times. The diversity receiver output SNR may now be easily calculated.

Each of the M signals will have a power B/M (for the average signal strength case) and the noise power accepted in receiving each of the M signals will be kB^2. The RF SNR at each of the M frequencies will be $1/MkB$ and coherent addition of M such signals will yield an output SNR of $1/kB$. So then

$$(\text{SNR})_{Div} = \frac{1}{kB} \quad (6)$$

on a power basis for a desired signal of mean strength. Note that in (6) we are able to specify the precise SNR, while in the SSB and DSB cases of (4) and (5) we can only predict the probability or the percentage time the SNR will exceed a given value.

III. Results and Discussion—Congested Band

The results represented by (4)–(6) may be interpreted in many different ways. For the purposes of this discussion let us assume that voice communications is involved and that message reception will be considered successful if the receiver output SNR equals or exceeds unity or 0 db. Keep in mind that this is not a commerical service but rather a service where the operator is willing to exert some effort in order to understand what is being said. Thus, the 0-db choice is probably reasonable with regard to sentence intelligibility where the interference is of an incoherent nature. The three equations will then be used to calculate the circuit reliability for signals at 0, +3, +6, and +9 db relative to mean signal strength as a function of kB, the band loading expressed in average number of stations per audio bandwidth. The resulting graphs are shown in Figs. 2 through 5. Turning first to Fig. 2, which assumes a received signal of mean strength, we note that the circuit reliability drops rather rapidly with band loading for both SSB and DSB. SSB shows some advantage, but of a small amount, at loadings which result in a reasonable reliability percentage. An estimate of the increased number of users for the same performance which results from SSB use may be obtained by drawing a line horizonally from any given

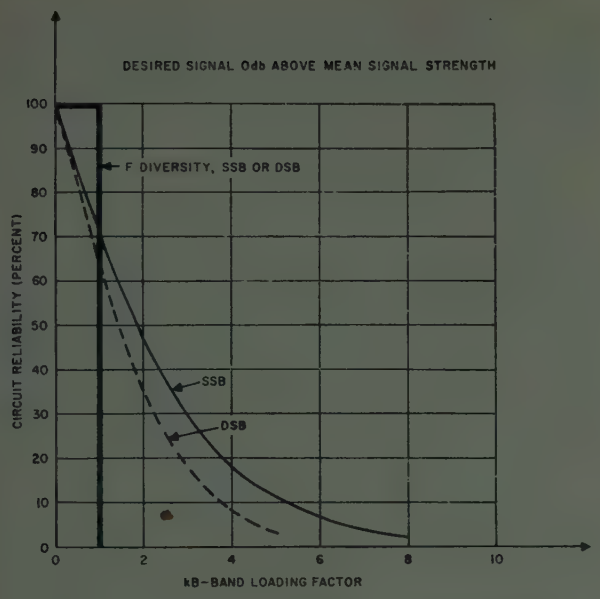

Fig. 2—Per cent circuit reliability vs band loading.

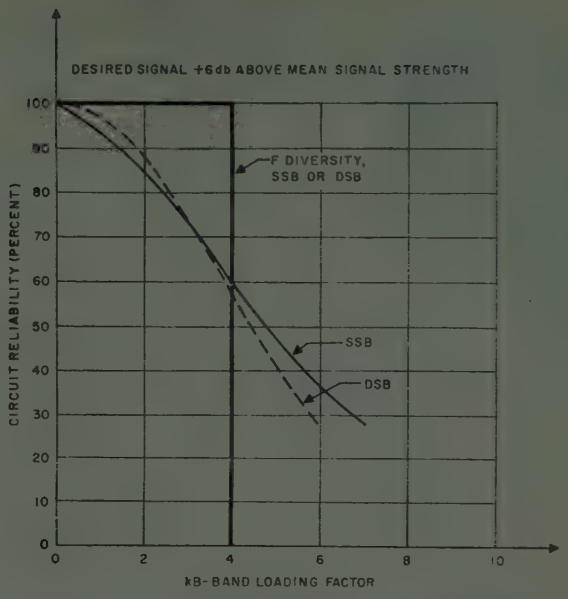

Fig. 4—Per cent circuit reliability vs band loading.

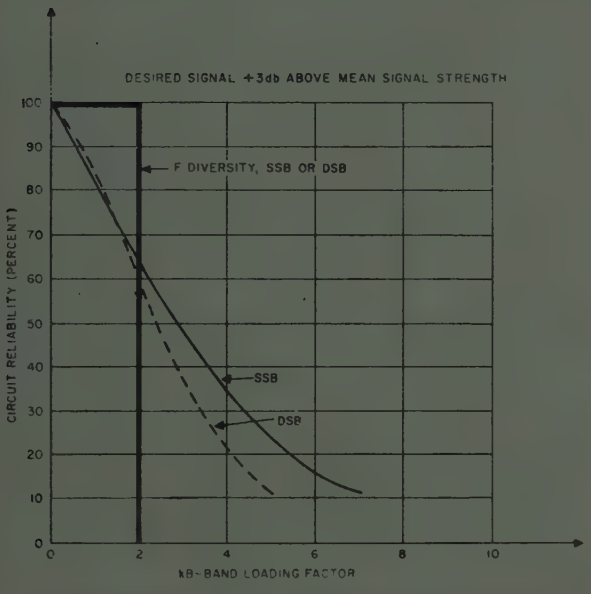

Fig. 3—Per cent circuit reliability vs band loading.

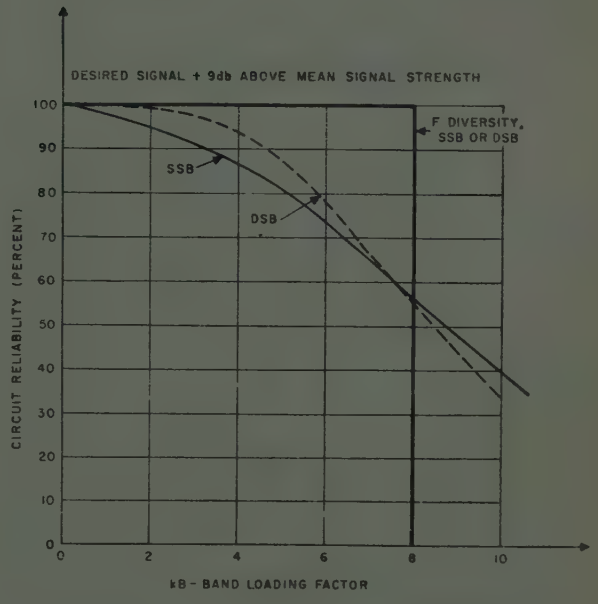

Fig. 5—Per cent circuit reliability vs band loading.

ordinate value and noting the kB values at which this line interesects the SSB and DSB curves. The two-to-one increase in loading which we might at first expect from SSB certainly does not materialize, except at values of circuit reliability which are so low as to be meaningless. Thus, the randomness of band occupancy has a significant effect on performance, and any intuitive conclusions based on orderly channel assignments are subject to considerable error. Note in particular that the circuit reliability for SSB at $kB = 1$ is 70 per cent. At this loading there are enough channels to satisfy all needs, and 100 per cent reliability could be had if some organization could be obtained. About the only conclusions to be drawn from Fig. 2 are that SSB and DSB give nearly the same performance and that it is usually hopeless to try to communicate with a station whose signal strength is only average at times when the band is crowded. This last conclusion will come as no surprise to the experienced operator.

As the strength of the desired signal increases above the mean value the situation improves rather rapidly, as shown by Figs. 3–5. The SSB and DSB curves now "cross over" and both curves tend to stay at higher reliability values as kB is increased, which is to be expected. Note in Fig. 5 that DSB shows a slight advantage over SSB for the lower loading values and the cross-over occurs when the reliability factor is 63 per cent. In total these results show the futility of claiming

any advantage for either SSB or DSB in this service. If one is insistent upon claiming an advantage, the specific conditions under which the comparisons are made must be given.

In our attempt to determine the sensitivity of the calculated results with respect to the choice of the amplitude distribution function, an exponential distribution was tried in place of the chi-squared. The exponential distribution gave more weight to signals above the mean than did the chi-squared. However, the final results were very nearly the same. A further calculation involving a delta-function distribution (all interfering signals of the same strength) showed no significant differences. Thus, one is led to believe that the results obtained are not particularly sensitive to the choice of any reasonable distribution function for the signal strengths.

The performance of the frequency diversity system shows up in a rather unusual manner in the graphs. This is due in part to the way in which we chose to interpret the results, and in part to the fact that in this case the interference is not random but constant. In the narrow-band cases the interference level changes considerably in short periods of time because of the random appearances and disappearances of signals close to the operating frequency. In the broad-band case, the interference observed is the net result of *nearly all* the stations on the band so that the actions of *any one* station have a negligible effect on the interference level at the output of an appropriate broad-band receiving system. Thus, for a given loading, the interference level stays fixed and only the signal strengths of the various stations to which the receiver is "tuned" will be found to vary. Some signals will be sufficiently above the noise to be understood all of the time, while others will be below the noise and will not be heard at all. We have made a rather interesting trade in going from narrow- to broad-band operation. In narrow-band operation, we can copy a strong signal most of the time and a weak signal just part of the time. In broad-band operation, we can copy a strong signal all of the time but a weak signal cannot be copied at all. The reason for the shape of the frequency diversity curves should now be clear, and the nature of the "trade-off" may be evaluated by an examination of Figs. 2–5.

Amateur band operation with broad-band systems will prove to be somewhat different in certain respects. There will be fewer stations with which contact may be established (since the weaker signals which were formerly heard intermittently will now not be heard at all), but once contact is established the conversation can be expected to continue without interruption for a considerable period of time. Since the amateur is not normally concerned with communicating with a specific person, the exchange of some freedom of choice of possible contacts for reliability of communications will probably be welcomed.

In the case of military communications, the problem is more difficult, since specific messages must be transmitted to specific stations. If the signal strengths are weak, the narrow-band approach certainly offers no solution since, as we have seen, the circuit reliability will be poor. The message will have to be repeated over and over again before it is received with any reasonable degree of completeness and accuracy. Thus, under such adverse conditions *we have been forced to lower the data rate* because the necessity for repetition has increased the time required for the transmission of a given message. Broad-band operation under the same adverse conditions will suffer the same fate, but to a lesser degree. The data rate will have to be lowered (this can be done without decreasing the bandwidth) but since the interference level will be fixed at some average value we can lower the rate by just the amount necessary to keep the error rate below the acceptable maximum. With narrow-band operation, practical considerations will no doubt force us to reduce the data rate to a value determined by the *maximum* interference level. Thus, for congested-band operation, broad-band systems appear to offer a more orderly approach to the problem and a potentially higher average traffic volume than narrow-band systems.

Nothing that has been said so far should be construed as meaning that broad-band systems will always give us the traffic volume we would like to have, or feel we must have to support operations. As the congestion becomes worse it will be impossible to avoid reducing the data rate per circuit. The important point here is that the broad-band philosophy *accepts interference as a fact of life* and an attempt is made to do the best that is possible under the circumstances. The narrow-band philosophy essentially denies the existence of interference since there is an implied assumption that the narrow-band signals can be placed in non-overlapping frequency bands and thereby prevent interference. It is perhaps redundant to state that the realities of most practical military situations almost completely destroy the validity of such reasoning.

At this point we shall leave the problem of the radio amateur and turn our attention to other communications areas. We have seen that the operating environment of the amateur is not unique to his service but that in other services, especially the military, conditions in actual practice will quite often degenerate to the congested situation of the amateur service. Under such conditions we have shown the necessity for a statistical approach to the problem. It has been further demonstrated that the efficient use of additional transmission bandwidth does not constitute a "waste" in the basic sense of the word. The policy of "conserving bandwidth" is not based on sound physical principles but is based rather on a very common but still myopic view of communications. Such a policy will, in many situations, conserve only the opportunity to communicate as efficiently as might otherwise be possible. Even worse, this point of view quite often leads to the design of systems which have little or no true military capability

because of extreme sensitivity to intentional interference. These and other matters will be discussed in Sections VI and VII in more detail. First, it is necessary to derive some rather simple results from information theory.

IV. Information Theory

Consider the problem of data transmission by electrical means. We transmit pulses over a noisy circuit and the pulses, together with the noise, are received and interpreted. Errors in interpretation of the message occur because of this noise. If the error rate is too high and the transmitter power is fixed, we have traditionally lowered the data rate in order to reduce the errors. This has always worked and the reason given was very simple. A lower data rate means that the pulse lengths can be increased, which in turn allows narrower bandwidths to be used, thereby reducing the amount of noise accepted by the receiver. Thus, it became axiomatic that lower error rates could be obtained only by corresponding decreases in bandwidth and data rate. To almost everyone in the communications art the validity of this axiom was unquestioned since there was a great deal of experience in support and none in contradiction. It remained for Shannon to show that systems could be constructed, in theory at least, which would behave quite differently from what our previous experience would lead us to expect. First of all, he showed that the data rate could be held at a constant value (provided this value were below a certain maximum) and at the same time the error rate could be reduced to arbitrarily small values. As for the general belief that one should always use the minimum possible bandwidth in order to reduce the noise accepted by the receiver, Shannon showed that in the ideal case, with a white-noise background, the system bandwidth should be increased to the point where the accepted noise power is at least equal to the signal power.[3] This new theory presented a radically different picture of the limiting behavior of communications systems.

A very superficial study of Shannon-type systems will now be made in the belief that many readers, who are not specialists in information theory, might find a practical discussion of this topic interesting and perhaps useful. Fig. 6 shows a form of communications system suggested by Shannon's work. The channel has a bandwidth W and average (white) noise power N. The transmitter is limited to an average power P. Consider a white-noise generator having a bandwidth W. We record M different samples of the generator output, each sample having a duration of T seconds. These waveforms are now designated $f_1(t)$, $f_2(t)$, $f_3(t)$, $\cdots$, $f_k(t)$, $\cdots$, $f_M(t)$ and are made available as transmitted symbols, as indicated in the figure. Copies of each of the M waveforms are made and placed at the receiver in the corresponding operator units $O_1, O_2, \cdots, O_k, \cdots, O_M$. In operation, one of the M waveforms (say the kth one) is selected for transmission. Waveform $f_k(t)$ plus channel noise is received by each of the operator units. The operator units subtract the waveform stored within each unit from the received signal, square this difference, integrate the square for T seconds (which is the duration of the symbols), and indicate this mean-square value as shown. If T is sufficiently large, each meter (except for the kth one) will with almost unit probability read very nearly a value corresponding to $2P+N$, which is the average power of the difference voltage in each case. The kth meter will give a reading corresponding to very nearly N (again with almost unit probability), since the $f_k(t)$ portion of the received signal is completely removed in the subtraction process and only the channel noise remains. Thus, by noting which meter has the lowest reading we can identify which of the M symbols was transmitted. Of course, because of the channel noise we will make an occasional error and identify the wrong symbol.

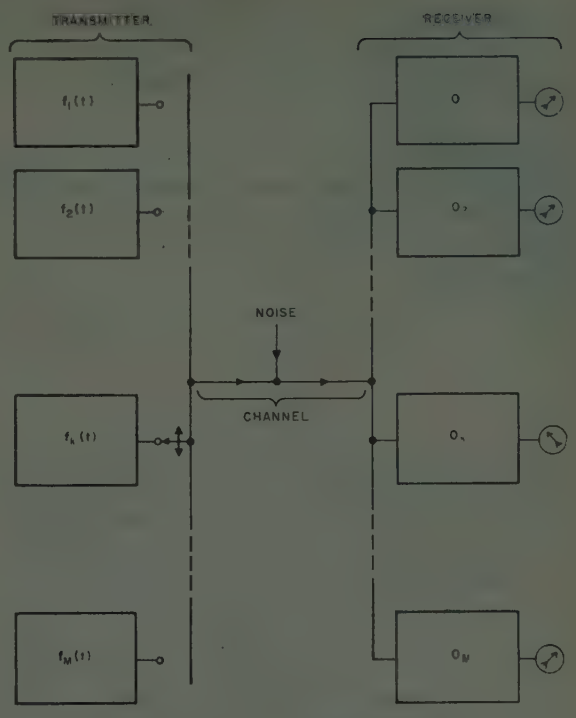

Fig. 6—An ideal communications system.

Before investigating the problem of errors we should examine the relationships between data rate R, symbol duration T, and number of symbols M. Assume that in each T seconds of time the system receives S binary digits (0, 1) to transmit. R will then be S/T bits per second. Since our symbol length is T, we must be prepared to indicate a choice of one out of 2^S possibilities with each symbol transmitted, since this is the number of different sequences of S binary digits. Then clearly

[3] C. E. Shannon, "Communication in the presence of noise," Proc. IRE, vol. 37, pp. 10–21; January, 1949.

$M = 2^S$ and

$$R = \frac{S}{T} = \frac{\log_2 M}{T} \text{ bits per second.} \quad (7)$$

Note that if the symbol length T is increased, the number of symbols M used must increase *exponentially* with T in order to keep a constant data rate. Thus, if T is *doubled*, M will have to be *squared* for the same data rate. In general terms

$$M = A^T \quad (8)$$

and

$$R = \log_2 A. \quad (9)$$

Returning again to Fig. 6, assume the kth symbol has been transmitted. Thus, we look to see if the kth meter gives the lowest reading. If this is so, there is no error. If any one of the other meters gives a lower reading, an error in selection will occur. The probability that any meter will read less than the kth one can be made progressively smaller by increasing T, which increases the integration time in the operator units. However, this is only part of the story. As T is increased to lower the probability of any one meter indicating lower than the kth, the number of such comparisons needed rises according to (8) in order that the data rate remain fixed. Thus, we have two conflicting trends as T is increased. The probability of error per comparison drops, but the number of comparisons necessary to arrive at a selection rises with increasing T. Shannon shows that we can always reduce the over-all probability of error in selection to as small a value as we may choose by letting T become large, *provided* that M does not increase with T faster than

$$M = \left(1 + \frac{P}{N}\right)^{TW}. \quad (10)$$

This maximum permissible rate of increase of M with T determines the maximum data rate which can be supported with an arbitrarily small error rate. This maximum rate is known as the channel capacity C and is obtained by substituting (10) into (7) to obtain

$$C = W \log_2 (1 + P/N). \quad (11)$$

Of course, we do not have to send data at the rate given by (11). We may send slower, and enjoy arbitrarily low, error rates. We may even send faster than C, but then we must accept a certain irreducible error rate.

As remarkable as (11) may be, the engineer concerned with practical system design needs more information than has been given thus far. We now know that multisymbol systems of the type shown in Fig. 6 are capable, practical considerations aside, of making the most efficient possible use of the communications channel. There are two engineering constraints which must be considered carefully. First, there is an inherent delay of $2T$ seconds involved in data transmission because a T-second length sample of input binary data must be available before choice of transmitted symbol may be made, and another T seconds is required for processing at the receiver before identification may be made. What will be the order of magnitude of this transmission delay? Secondly, how many different symbols M will be required in a given situation? This last consideration is of special importance because it determines, rather directly, system complexity. We might suspect that any attempt to operate at or very near the rate C would require intolerably large T and M since this rate represents a limiting condition. Similarly, large T and M would be expected to result at operating rates lower than C if the error rate is specified at a very small value. What we really need to know is the behavior of T and M for a practical error rate, say 10^{-5}, as the data rate is varied from zero to 100 per cent of capacity. Rice, in an excellent paper,[4] gives us a good indication of the orders of magnitude involved. Rice assumed an SNR of 10 and an error rate of 10^{-5}. He then determined the number of bits per symbol S which would be necessary for various values of the ratio of actual data rate to channel capacity. The results are shown plotted in Fig. 7. Notice

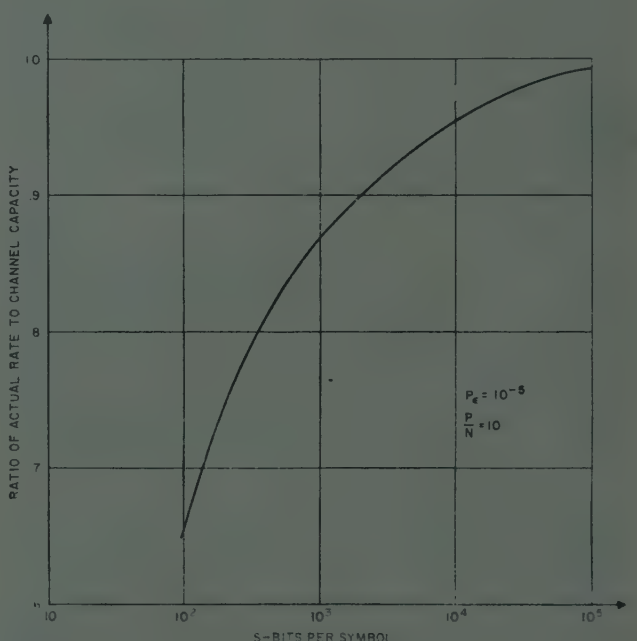

Fig. 7—Curve from Rice showing approach to capacity.

that the numbers S of bits per symbol are quite large, and keep in mind that the number of symbols M is 2^S. We need no numerical examples to conclude that the number of symbols needed will be fantastically large and that it is completely impractical to attempt to build systems which operate at rates close to the Shannon capacity under the conditions assumed above. (An

[4] S. O. Rice, "Communication in the presence of noise," *Bell Sys. Tech. J.*, vol. 29, pp. 60-93; January, 1950.

interesting piece of work by Stutt[5] shows that the situation is not quite so unreasonable if the SNR is low and the symbol waveforms are chosen systematically rather than at random.)

In brief retrospect, we (as communications engineers) have been shown by Shannon that there is an upper limit to what we can do no matter how hard we may try or how ingenious we may be. That it may be extremely difficult to achieve or even approach this upper limit in practice can hardly be blamed on Shannon. He has located the top of our mountain; the problem of reaching the peak is ours, not his.

V. A Practical System of High Efficiency

It is quite clear that any analysis of a communications problem which uses the capacity formula without careful qualification may give results of doubtful practical value. If a system of high efficiency and of reasonable complexity could be found, perhaps problem analysis could be carried out with results which would be significant in practice. Consider once more the system of Fig. 6, but now let there be only two symbols used, $f_1(t)$ and $f_2(t)$. Shannon's idea of using noise-like symbols is quite intriguing. This will be retained except that $f_2(t)$ will be the negative of $f_1(t)$ instead of being chosen at random as before. Thus, $f_1(t)$ is now transmitted for mark (or binary 1) and $-f_1(t)$ for space (or binary 0). For obvious reasons we shall refer to this two-symbol system as the binary system.

In the analysis of this binary system it is convenient to recall one form of the sampling theorem which states that a time function of T-seconds duration and of W-cycles bandwidth is completely specified by $2TW$ equally-spaced sample values of the funtion. Thus, we will represent the function $f_1(t)$ by the sequence of numbers $\{x_1, x_2, \cdots, x_{2TW}\}$, which are the values of the function at the sampling times. The function $f_1(t)$ will be noise-like except that we shall adjust the function so that we obtain the exact relationship

$$\frac{1}{2TW}\sum_{1}^{2TW} x_j^2 = P, \tag{12}$$

where P is the average transmitter power. In a like manner the channel noise, which has an average power N, will be represented by the sequence of numbers $\{n_1, n_2, \cdots, n_{2TW}\}$, where the n_j are independent normal variables with zero mean and variance N. If one performs the operations described for Fig. 6 one obtains the following for the probability of error P_e:

$$P_e = \text{Prob.}\left[\frac{1}{2TW}\sum_{1}^{2TW} x_j n_j < -P\right]. \tag{13}$$

The summation term may be shown to be Gaussian with zero mean and variance $PN/2TW$. If operating conditions yield a low error probability, then

$$P_e = \frac{e^{-\gamma}}{2\sqrt{\pi}(\gamma)^{1/2}}, \tag{14}$$

where

$$\gamma = \frac{P}{N}TW. \tag{15}$$

A plot of $\log_{10} P_e$ as a function of γ is shown in Fig. 8.

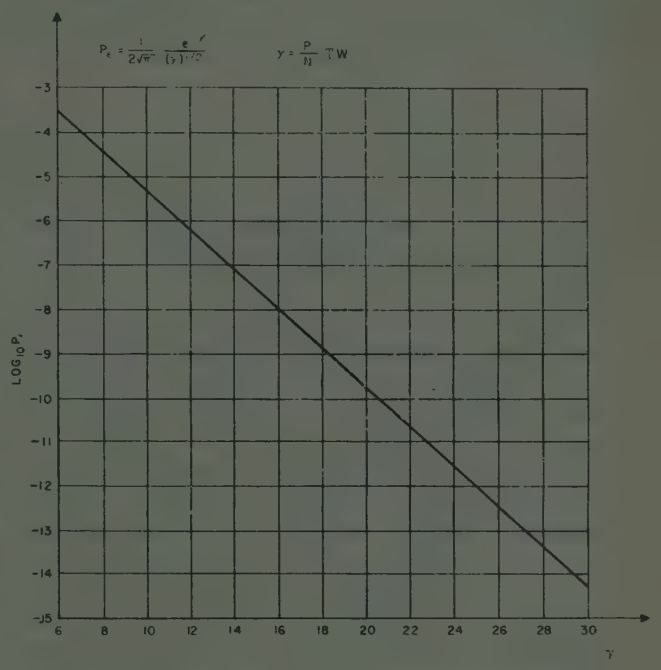

Fig. 8—Plot of $\log_{10} P_e$ vs γ for the binary system.

Note that once the system error probability is fixed, the relationship between SNR, bandwidth, and data rate ($1/T$ bits per second) is immediately determined.

We might inquire now as to how good our binary system is. It is certainly as good as any two-symbol system can be. Better results can be obtained only by increasing the number of symbols. The gain in doing this, however, does not generally appear to be worth the effort. For example, Stutt[5] shows that for a P/N of 1/10 and error probabilities in the neighborhood of 10^{-4} to 10^{-6}, the most efficient symbol choice requires the use of about 100 symbols in order to increase the data rate over binary by a factor of five. Note, however, that at a fixed error rate the data rate of the binary system may be made 5 times as large by inceasing transmitter power by 7 db. Thus, we must evaluate the relative costs of a 7-db transmitter power increase vs the increase in symbols from two (actually one in terms of equipment complexity) to 100. We must conclude, therefore, that our binary system performance represents about the best that can be done in practice. Better results may be obtained by using more symbols but the rate of improve-

[5] C. A. Stutt, "Regular Polyhedron Codes," Research Laboratory, General Electric Co., Schenectady, N. Y., Tech. Rept. No. 59-RL-2202; February, 1959.

ment will generally prove to be low.[6]

This places us in a good position to derive expressions for the channel capacity in the practical case from (14) and (15). Before doing so we should understand that for high SNR's these equations may yield rates in bits per second far in excess of the bandwidth in cycles per second. There is a mathematical limitation which prevents this. This limitation will not be discussed except to mention the fact that in theory the binary system is limited to a maximum rate $2W$ regardless of SNR.[7] In practice it is usually quite difficult to achieve even W as a rate; we shall choose this as our limiting value.

Since the rate R is $1/T$, the channel capacity C_p in the practical case may be obtained from (15) as

$$C_p = \frac{W}{\gamma}\frac{P}{N}, \tag{16}$$

$$C_p \leq W, \tag{16a}$$

where γ is fixed by the desired error probability according to (14). For an error probability of 10^{-5}, γ is approximately 9.2.

Admittedly, the result (16) is not as elegant as (11). Keep in mind, however, that the concise nature of the capacity formula (11) is made possible by a limiting process in mathematics which cannot be duplicated in practice. A valid objection could also be raised to the application of the term "capacity" to the rate indicated by (15) and expressed in (16). From purely theoretical considerations, such an objection is certainly justified. From a practical point of view, (16) does, in a sense, qualify as a capacity since the performance indicated may only be approached by the most efficient use of modulation and processing techniques. It is quite doubtful that there exist at present any operating systems which perform as well as (16) indicates is obtainable. The main point to remember is that for many years to come (16) will represent a sensible, realizable (but not easily realizable) design goal for the communications engineer; the capacity formula (11) can never serve this purpose. As processing and storage techniques improve, it is to be expected that at some future time multisymbol systems may be built whose performance will exceed that indicated by (16). This does not in any way lessen the utility of (16) as a frame of reference.

VI. Jamming

From the work of the previous section, we now derive some rather simple results which are well-known to information theory specialists the world over, but whose significance is apparently not appreciated by many engineers, at least in this country.

Consider first the performance of the binary system in a white-noise background having a density of n_0 watts per cycle. The effective noise power N will then be

$$N = n_0 W, \tag{17}$$

and (15) will read in this case

$$\gamma = \frac{PT}{n_0} = \frac{E}{n_0}, \tag{18}$$

where E is the energy per transmitted symbol. We now have derived the well-known result that for binary systems of this type operating against flat channel noise, the error probability is independent of bandwidth and is a function only of energy per symbol and noise power density. Thus, for fixed average signal power and fixed data rate, the error probability does not change as the system bandwidth is increased. It is clear that as the bandwidth increases, the noise power accepted by the receiver increases, and for large bandwidths the received noise power becomes quite large compared to received signal power. Thus, systems of this type can operate with SNR's far below unity, or put another way, these systems can be made to operate satisfactorily in the presence of very large amounts of noise power. One might begin to suspect that a broad-band system would be fairly immune to intentional jamming, since in normal operation it is contending (satisfactorily) with such large amounts of natural noise that the additional noise contributed by the jammer would be insignificant by comparison. That this is precisely the case will be made more definite in what follows.

Consider a binary communications system designed to operate in a white-noise background of power density n_0 watts per cycle. Let practical considerations demand that the error probability be kept at or below a critical value P_{e0} corresponding to a γ value of γ_0. Then the channel capacity will be from (16):

$$C_p = \frac{W}{\gamma_0}\frac{P}{n_0 W} \tag{19}$$

as far as natural noise is concerned. For the sake of argument, we shall choose to operate at a data rate R corresponding to one-half capacity. Then,

$$R = \frac{1}{T} = \frac{C_p}{2} = \frac{P}{2\gamma_0 n_0}. \tag{20}$$

Consider now the appearance of a jamming signal of average power J in the channel and let us investigate the effect of J on γ, since this factor must be kept above the assumed critical value of γ_0. The noise term N in (15) will now be

$$N = n_0 W + J, \tag{21}$$

and when (20) and (21) are substituted into (15) we obtain

$$\gamma = \gamma_0 \frac{2n_0}{n_0 + J/W}. \tag{22}$$

[6] This, like all generalizations, will have exceptions. One can conceive of situations in which the multisymbol system would have sensible application. In such cases the work of Stutt, *ibid.*, should prove quite useful.

[7] See discussion of sampling theorem which precedes (12).

This last equation tells a very interesting story. First of all, note the appearance of the J/W term in the denominator. This indicates that the effectiveness of a given average jamming power varies *inversely* as system bandwidth. The broader the bandwidth the less effective will be the resultant jamming. In particular, in order to disrupt the circuit ($\gamma=\gamma_0$) one needs an amount of average jamming power J_0 equal to

$$J_0 = n_0 W \tag{23}$$

under the conditions specified. Thus, the relationships between bandwidth and jamming power become quite clear and may be summarized as follows: *If the most efficient system design is assumed for a fixed data rate in each case, the necessary power required to jam the ciruit varies in direct proportion to system bandwidth. The broader the bandwidth the more difficult it will be to jam the circuit. Conversely, the narrower the bandwidth the easier it becomes to jam the circuit.*

It should be quite clear that if intentional jamming is a consideration, one must of necessity choose a broad-band technique. The narrow-band approach can only lead to eventual disaster.

VII. The Question of Channels

The well-known, but not necessarily sufficiently appreciated, relationship between jamming immunity and system bandwidth discussed above leads to a natural concern over loss of channels if broad-band techniques are employed, as obviously they must be in many applications. It is the purpose of this section to discuss the general problem of "channels" somewhat more thoroughly than before, through use of the practical channel capacity formula (16).

Consider the following problem. Communications service must be provided which requires that a total of K stations be permited to transmit messages at *any* time. Let α be the average fraction of time each station is active. The average signal strength (power) at a particular receiver will be denoted by $\overline{P}$ and it is assumed that Ω cycles of total bandwidth are allocated to this service. Background or natural noise will be ignored. Thus:

Ω = Total bandwidth allocated to service.
K = Number of stations, each of which must be permitted to transmit at any time.
α = Average fraction of time each station is actually transmitting.
$\overline{P}$ = Mean signal power at a receiving site (one station).
C_{pN}, C_{pB} = Practical channel capacity per circuit in narrow- and broad-band operation, respectively.

We now wish to inquire as to the relative merits of narrow- and broad-band techniques for this service.

First let us assume an environment in which *all* stations are under the complete control of a central authority. Under this special condition, frequency division will result in circuit bandwidths of Ω/K and, since there will be no interference and background noise is ignored, the capacity per circuit will be, using (16a),

$$C_{pN} = \frac{\Omega}{K}. \tag{24}$$

By comparison, the broad-band approach would yield a circuit bandwidth of Ω and a noise power N of $\alpha K\overline{P}$, which, if an average strength signal were being received, would result in a capacity per circuit of

$$C_{pB} = \frac{\Omega}{\gamma\alpha K}, \tag{25}$$

using (16). Comparing (25) and (24) we see that if such a well-disciplined environment can be found, the narrow-band system would be superior *provided* that the duty cycle factor α is kept high. For example, if $\alpha=1$ (each station transmitting continuously) the narrow-band system appears to offer about a ten-to-one data rate advantage (for $\gamma=10$). If, due to operational considerations, the average duty cycle is low (say, 10 per cent or even 1 per cent or less as may quite often be the case), then the broad-band system, even under such ideal conditions, becomes superior.

The reasons for this are quite clear. If the duty cycle is low, the narrow-band system wastes spectrum since most of the allocated channels in Ω will be idle at any time. This cannot be avoided since each of the K stations must have access to communications at any time. The broad-band system takes immediate advantage of a low-duty cycle since this keeps the "noise" level at low values and increases the per-circuit capacity. The narrow-band approach guarantees complete elimination of interference between stations (orthogonality, as the specialist would say), while in the broad-band case each station appears as noise to the others. Thus, at high duty cycles the narrow-band system is superior because it avoids this "noise" problem completely. We must conclude then that the narrow-band system has sensible application under very special conditions (such as in radio broadcasting), but that even where complete control of all transmitters is possible, the broad-band system can easily prove to be the more efficient user of spectrum.

We shall now consider the same communications service problem as before, except that we shall abandon any hope of a disciplined use of the bandwidth Ω. In most military applications, a congested band assumption is much more realistic for several reasons. Certainly two opposing military forces will have planned their spectrum usage independently. Under such conditions interference will be the expected rather than the unusual event. If narrow-band systems have been chosen, it is quite likely that each operator will shift frequency when severe interference is encountered in an attempt to maintain service. This is only the natural and sensible

thing to do. Furthermore, under conditions where signals propagate over distances of many thousands of miles, interference will no doubt be quite common even between stations that are a part of the same military force. It seems unrealistic to expect that interference can be prevented by administrative means when the total number of users is large and when the geographic distances between groups of users is great. It must be presumed then that, in spite of careful allocation attempts, the narrow-band approach will not prevent interference and that congested operating conditions will certainly prevail.

Consider the problem that an operator faces when trying to clear messages in a congested band using narrow-band systems. As we have shown, the SNR in such a case is a statistical quantity varying from very good at one time to hopelessly poor minutes or even seconds later. If the data rate is set too high (based on those times when the SNR is good), much of the traffic will be lost and repetition will be necessary. In order to know what messages or parts of messages were lost, a return link is required, but this will also suffer from interference. Such operation is quite inefficient and it would soon be discovered that the data rate would have to be determined by the *least favorable* SNR anticipated during the operating period. Thus, the per-circuit channel capacity in this case may be approximated roughly by

$$C_{pN} = \left(\frac{P}{N}\right)_{\min} \frac{\Omega}{\gamma K}, \tag{26}$$

using (16).

The assumption of congestion does not alter the performance of the broad-band system so that (25) still holds. A rough estimate of the relative performance of these two approaches to the problem of congested band operation may now be obtained by taking the ratio of (25) to (26):

$$\frac{C_{pB}}{C_{pN}} = \frac{1}{\alpha(P/N)_{\min}}. \tag{27}$$

As rough as this approximation may be it still seems rather certain that in a congested band the broad-band system will normally far outperform the narrow-band system.

Eq. (25) may then be taken as the average capacity per circuit of a congested band. In slightly modified form we have:

$$C_{pB} = \frac{1}{\gamma k} \text{ bits per second}, \tag{28}$$

where k is the average number of actual users per cycle of bandwidth and γ is determined by the required error probability according to (14).

It might be mentioned at this point that with broad-band operation the DSB and SSB methods of modulation give identical results for the same transmission bandwidth. As a practical matter, the DSB system offers a two-to-one increase in transmission bandwidth in the modulation process over and above the bandwidth increase obtained by coding processes at baseband. This may sound strange to engineers accustomed to design work aimed at conserving bandwidth. It is still true that there are practical difficulties involved in designing equipment which uses more bandwidth *efficiently* and that the bandwidth doubling which may be obtained in the modulation process with DSB will prove quite helpful in general.

VIII. Conclusions

Since the invention, many years ago, of the frequency-selective filter, it has been common practice to share the inherent capacity of the RF spectrum among users on the basis of frequency allocations. As the number of users increased, methods were found for reducing transmission bandwidths so that new services could be accommodated in the existing spectrum. Extrapolating the past into the future has led to the natural attempt to continue this evolutionary process of seeking methods for the further narrowing of transmission bandwidths, thus providing service for the increasing user population.

This philosophy of spectrum usage is based on a particular course of development which the radio art happened to take, rather than on any fundamental physical principles. The inherent communication capacity of the spectrum can be shared in ways other than by frequency allocation and for many applications the frequency division approach represents a very poor choice indeed. In the field of military communications in particular, the tendency to follow the trends of the past quite often leads to systems having negligible military capability although good intentions may be to the contrary.

This is not to say that broad-band systems have been completely ignored in the past. It could safely be said, however, that the magnitude of the effort thus far expended on the broad-band approach is far out of proportion to the importance of this technique.

Acknowledgment

The author wishes to express appreciation to his many colleagues at the General Electric Company who assisted in the work upon which this paper is based. Special thanks are due to J. C. Kovarik who contributed much original material for the congested-band analysis and to S. Applebaum and Dr. H. D. Friedman for their constructive discussions of information theory problems.

Electronic Scanning System for Infrared Imaging*

M. E. LASSER†, P. H. CHOLET†, AND R. B. EMMONS†

Summary—**A new all electronic infrared imaging system has been designed and constructed. The infrared image of a given field of view is focussed onto a scanning tube which dissects the image; after passing through the scanning tube, the radiation is then refocussed onto a separate infrared detector. The tube face is a semiconducting window. An electron beam, striking the window, generates free carriers and reduces the transmission of the window locally. As the electron beam is swept across the scanning tube face, the moving opaque spot produces a video signal at the detector. Both the conditions for the operation of the device and the over-all sensitivity have been analyzed. It is found that the sensitivity and information rate of the system are limited only by the sensitivity and time constant of the detector employed.**

Introduction

THE problem of conversion of an image formed by infrared radiation to a visible image has been approached in a number of ways.

Mechanical scanning systems have undergone years of study, and have extremely varied forms[1] but suffer from scanning speed limitations. Photoemissive image tubes developed to date suffer from serious limitations in wavelength response, and vidicon or photoconductive tubes which show promise of long wavelength sensitivity appear to be limited by the fact that the very high resistivity required by the screen material can only be achieved by cooling the entire sensitive area.

Following the suggestion of one of the authors (M. E. Lasser), a high-speed electronic scanner has been constructed and tested in the laboratory. This tube does not have the storage capabilities of a vidicon, but it is extremely easy to construct, and has proven to be a practical operating device when used with any one of several highly sensitive, small-area infrared detectors.

The infrared scanner consists of a tapered tube with a semiconducting window at one end and any suitable infrared transparent window at the other. Another tube, containing an electron gun, is joined to the first at an angle which allows the electron beam to strike the semiconductor, but which keeps the gun out of the optical path between the two windows.

An infrared image of the object to be viewed is formed on the semiconducting window. When the electron gun is not operating, the infrared radiation continues through the second window of the tube. It is then reimaged on the surface of an infrared sensitive detector.

When the beam is turned on and focused on the first window, the moderately high-energy electrons create free carriers locally in the semiconductor, changing its conductivity and, hence, its absorption coefficient at that point. Deflection yokes allow the beam and the absorbing spot which it generates to be swept over the semiconductor to form a raster. Since the amount of light absorbed at any instant depends on the intensity of the infrared image under the absorbing spot, the output of the detector will be a time function whose amplitude is dependent on the spatial intensity variations in the infrared image. This time function may be used to modulate the beam of a television-type monitor, thus rendering the infrared image visible.

Theory

Free Carrier Absorption

We will first determine the increase in free-carrier density which is required to make the semiconductor locally opaque, and whether it is possible to produce this required density through the action of an electron beam.

A qualitative explanation of the optical properties of semiconductors at wavelengths too long to produce absorption by means of valence to conduction band transitions may be obtained from the classical Drude-Zener theory. Later work,[2,3] has produced no essential modification of the classical theory, and none of the theories is as yet in very good quantitative agreement with experimental absorption data. The classical theory, adjusted to fit the experimental data, will be used here.

According to the Drude-Zener theory, the absorption coefficient α of a semiconductor for light of angular frequency ω is given by

$$\alpha = \frac{1}{c\epsilon_0 n}\sigma \tag{1}$$

where

$$\sigma = \sigma_0\left(\frac{1}{1+\omega^2 t^2}\right), \tag{2}$$

σ is the frequency dependent conductivity,
σ_0 is the dc conductivity,
ϵ_0 is the permittivity of free space,
n is the index of refraction,
c is the velocity of light, and
t is the mean time between collisions for the charge carriers and is related to the drift mobility μ of the free carriers present by the expression $t=m^*\mu/q$ where m^* is the effective mass of the free carriers and q is their charge.

* Original manuscript received by the IRE, July 14, 1959; revised manuscript received, September 28, 1959.

† Philco Corp., Philadelphia, Pa.

[1] J. C. Wilson, "Television Engineering," Pitman and Sons, Ltd., London, Eng., ch. 1; 1937.

[2] R. de L. Kronig, "The quantum theory of dispersion in metallic conductors, part II, *Proc. Roy. Soc. (London)*, vol. 133, pp. 255–265; September, 1931.

[3] H. Y. Fan, W. A. Spitzer, and R. J. Collins, "Infrared absorption in *n*-type germanium, *Phys. Rev.*, vol. 101, pp. 566–572; January, 1956.

For most semiconductors, t is in the range 10^{-13} seconds to 10^{-12} seconds. Thus, for wavelengths from the absorption edge to wavelengths well beyond 20 μ, $\omega^2 t^2 \gg 1$, and we may use the approximation

$$\alpha = \frac{1}{4\pi^2 \epsilon_0 n c^3 t^2} \sigma_0 \lambda^2 = C\sigma_0 \lambda^2. \tag{3}$$

The value of the constant C as defined by (3) will not be used in the following. Instead, we will choose a value for C which brings the equation into better agreement with experimental absorption data.

In the wavelength range of interest, then, we can expect that the absorption coefficient will depend linearly on the conductivity and on the square of the wavelength of the incident light. Structure, such as that observed in the absorption curves of p-type germanium[4] superimposes additional absorption[5] which disturbs this functional dependence but this dependence is supported by the experimental data for silicon[6] (see Fig. 1), n-type germanium, and a number of other materials.[7]

The relative intensity of light transmitted through a semiconductor will then be (neglecting Fresnel losses)

$$\frac{I_1}{I_0} = e^{-C\sigma_0 \lambda^2 x} \tag{4}$$

where x is the thickness of the semiconductor window. Fresnel losses are independent of wavelength and conductivity for semiconductors in the wavelength region and with the conductivities σ_0, of interest here. When electrons strike the material, producing, to the depth of their penetration d, a higher conductivity σ_1, the relative transmission of the window becomes

$$\frac{I_2}{I_0} = e^{-C\sigma_0 \lambda^2 x} e^{C(\sigma_0 - \sigma_1)\lambda^2 d} \tag{5}$$

at the point where the beam strikes the material. If the material is to be made essentially opaque (<1 per cent transmission) the exponent of the right member of the expression must be at least 4.6. If we assume that $\sigma_1 \gg \sigma_0$ then the terms of the exponent involving σ_0 can be neglected.

Consequently the requirement for 99 per cent absorption is simply

$$C\sigma_1 \lambda^2 d \geq 4.6. \tag{6}$$

The conductivity σ_1 of the semiconductor at the point where the beam strikes it may be written

$$\sigma_1 = qn(\mu_e + \mu_h) + \sigma_0 \tag{7}$$

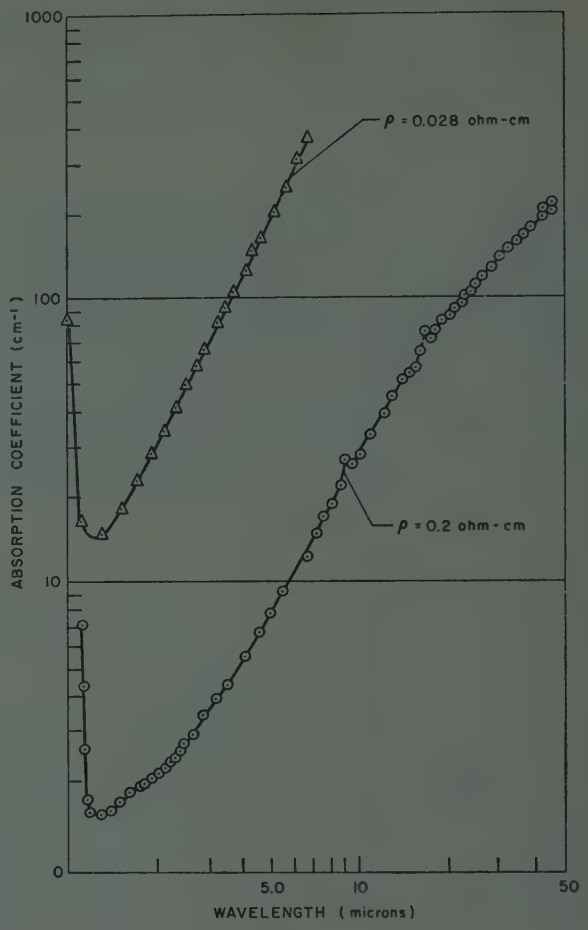

Fig. 1—Free carrier absorption in p-type silicon (after Spitzer).

where n is the steady-state density of the pairs of carriers created by the beam and μ_e and μ_h are the mobility of the electrons and holes, respectively. σ_0 will be again neglected in comparison with the first term. The steady-state density of pairs n may be written

$$n = g\tau \tag{8}$$

where g is the pair generation rate per unit volume and τ is the lifetime of the material. It is assumed that the beam dwells on any one spot at least long enough so that equilibrium is established between the generation and recombination rates. In terms of the beam current i and spot area s of the electron gun, and in terms of Z, the efficiency of production of pairs by the electrons, the generation rate is

$$g = \frac{Zi}{qsd} \tag{9}$$

where it has been assumed that the current density is constant over the area s of the beam. An empirical curve for Z, the number of pairs created by each electron as a function of its energy, has been reported for silicon[8] and

[4] W. Kaiser, H. Y. Fan, and R. J. Collins, "Infrared absorption in p-type germanium," *Phys. Rev.*, vol. 91, pp. 1380–1381; September, 1953.

[5] This additional absorption, which is due to intraband transitions, is useful in that it reduces the number of free carriers required to make the semiconductor locally opaque.

[6] W. G. Spitzer, "Infrared Properties of Semiconductors," Ph.D. dissertation, Purdue University, Lafayette, Ind., p. 50; 1957.

[7] H. P. R. Frederikse and R. F. Blunt, "Photoeffects in intermetallic compounds," PROC. IRE, vol. 43, pp. 1828–1835; December, 1955.

[8] V. M. Patskevich, U. S. Vavilov, and L. S. Smirnov, "Energy of ionization by electrons in silicon crystals," *Soviet Phys. JETP*, vol. 6(33), pp. 619–620; March, 1958.

is reproduced in Fig. 2. The curve is linear with a slope of about 1 pair/7 ev above 10 kev, and less than this below 10 kev, indicating that some energy is lost in penetrating the surface without commensurate production of hole electron pairs. The curve may be reasonably extrapolated to higher energies; the mechanism for the loss of energy of the electrons continues to be pair production by ionization up to the electron energies of 140–150 kev, at which point Frenkel defects begin to occur.[9] Thus if the electron beam energy is maintained below the 140-kev value, the bulk characteristics of the silicon will not be adversely affected by the incident electron beam.

We are now in a position to determine whether a local conductivity sufficient to produce complete absorption can be obtained. Substituting (7), (8), and (9) into (6), we have as the condition for 99 per cent absorption that

$$C\sigma_1\lambda^2 d = \frac{CZi\tau(\mu_e + \mu_h)\lambda^2}{s} \geq 4.6. \qquad (10)$$

Assuming the semiconductor is silicon, we take $C = 8 \times 10^6$ ohms^2/cm^2, $\mu_e = 1500$ cm^2/volt second, and $\mu_h = 500$ cm/volt second. The wavelength at which the inequality (10) is most difficult to satisfy is the shortest in the range of interest. Consequently, we take $\lambda = 1.2\ \mu$. Silicon may be obtained with lifetime τ ranging from 10^{-8} seconds to 10^{-3} seconds. We will choose, for the present, the easily obtained value 10^{-6} seconds. The depth of penetration of the electrons has canceled out of the above expression, but an estimate of its value will be required to insure the choice of silicon with the proper lifetime.

The penetration depth for 25 to 30 kev electrons is of the order of 10^{-3} cm, as estimated from the experimental data for aluminum,[10] whose density and atomic number are quite close to those of silicon. This depth of penetration is small enough so that the surface recombination lifetime may be expected to predominate over the bulk lifetime. Consequently when a silicon window is chosen for the tube, the lifetime should be measured with the surface finished as it is to be used, and nonpenetrating light should be used to take the measurement.

A triode gun of the type used in a flying spot scanner tube will yield a beam current i of 1.0 milliampere at an accelerating potential of 30 kv, with a spot diameter of 0.01 cm. Each of the electrons, accelerated to an energy of 30 kev, will yield 2800 pairs when it strikes the silicon. Substituting these numbers into (10), we obtain

$$C\sigma_1\lambda^2 d = 8.0.$$

Thus, we see that it is possible to produce a spot which is opaque even at the shortest wavelength of the useable range in silicon with a beam current which is easy to obtain. At the longer wavelengths, effectively complete absorption is obtained with currents well below 1 milliampere.

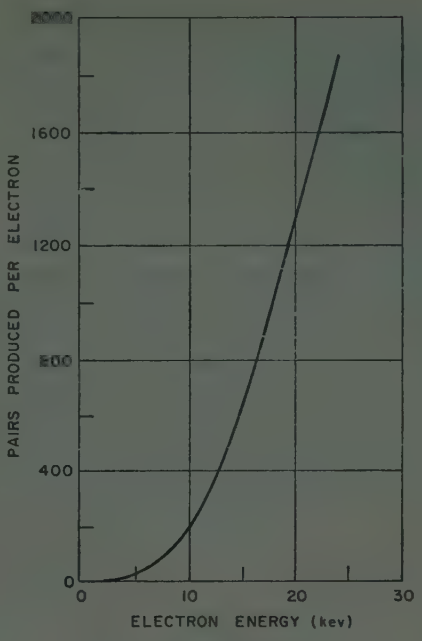

Fig. 2—Pair production in silicon by high-energy electrons (after Patskevich, Vavilov, and Smirnov).

In the design of the tube, it is important to insure sufficient absorption, both to produce maximum signal and to avoid the possibility of noise modulation of a less than fully opaque spot. Within this limitation it is necessary to consider the effect of the lifetime of the semiconductor on the bandwidth, the resolution, and the sensitivity of the system in which it is to be used.

The lifetime of the material should be chosen to match approximately the dwell time of the electron beam on any one spot. If the scanning rates are such that the beam dwells on one spot much longer than a lifetime, it becomes a relatively inefficient producer of free carriers. A longer lifetime would in such a case allow the beam current to be reduced while maintaining complete absorption. On the other hand, if the beam dwells on any one spot a time shorter than the lifetime of the material an after-image may result.

The diffusion length in the material determines how much the electron hole pairs created by the beam will spread before recombination. This spreading will put a lower limit on the spot size for material with a given lifetime. The average diffusion path length is given by

$$L_D = \sqrt{D\tau}$$

where D is the diffusion constant for the material, and τ is as before the lifetime. For silicon, $D \approx 20$ cm^2/second; hence, if $\tau = 10^{-6}$ seconds,

$$L_D = \sqrt{20 \times 10^{-6}} \approx 4.5 \times 10^{-3}\ \text{cm}$$

which will effectively double the size of the opaque spot

[9] P. Rappaport and J. J. Loferski, "Radiation damage in Ge and Si detected by carrier lifetime changes: damage thresholds," *Phys. Rev.*, vol. 111, pp. 432–439; July, 1958.

[10] L. Katz and A. S. Penfold, "Range-energy relations for electrons and the determination of beta-ray end-point energies by absorption," *Rev. Mod. Phys.*, vol. 24, pp. 28–44; January, 1952.

for an electron beam spot size of 10^{-2} cm. The resolution of the system will of course depend on the optical system used to place an image on the silicon as well as on the spot size given above, but the limitation arising from the diffusion of the pairs must be kept in mind.

Possibility of Reflecting or Refracting Mode

The possibility of using the scanning tube in the reflecting or refracting mode rather than the absorptive mode has also been considered theoretically. Noise arguments given below show that, in most practical cases, the decrease in sensitivity arising from the fact that the entire field of view is always on the detector is negligible. However, if the carriers created by the electron beam could change the index of refraction sufficiently, it would in principle be possible to have only a particular scanned element reflected or refracted onto the detector.

The reflection coefficient for normal incidence is given by

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2}$$

where n and k are the index of refraction and extinction coefficient respectively.

When there are no free carriers present $k=0$ at wavelengths longer than the band edge. To determine the effect of a change in the free-carrier concentration on the reflection coefficient we have to evaluate how large an effect the free carriers have on the values of n and k.

The optical constants are related to the conductivity and the dielectric constant by the following relationship.

$$K_e - \frac{j\sigma}{\omega\epsilon_0} = (n - jk)^2$$

where K_e is the dielectric constant and σ is the conductivity as measured at the angular frequency ω.

Solving for n and k we find

$$n^2 = \left[\sqrt{1/2 \quad K_e^2 + \left(\frac{\sigma}{\omega\epsilon_0}\right)^2} + K_e,\right]$$

$$k^2 = \left[\sqrt{1/2 \quad K_e^2 + \left(\frac{\sigma}{\omega\epsilon_0}\right)^2} - K_e.\right]$$

Since $K_e \approx 12$ for silicon, changes in n (or k if we are interested in a reflection change) due to changes in the free carrier concentration will not be significant unless

$$\sigma \geq \omega\epsilon_0.$$

This reduces to the condition that σ at 3μ must be greater than or equal 55 Ω^{-1} cm^{-1}.

Therefore, in order to obtain a change in the index of refraction at 3 μ, the dc conductivity as given by (2) must be at roughly 3.5×10^6 Ω^{-1} cm^{-1}, which will be difficult to achieve with injection by the electron beam. In contrast, note that from (6), the dc conductivity required to produce complete absorption at 3 μ is 1×10^4 Ω^{-1} cm^{-1}, somewhat more than two orders of magnitude less. At longer wavelengths, the magnitude of the dc conductivity required to produce a change in the refractive index will decrease, and the changes will be easier to achieve. Thus, if the tube is to be used at wavelengths of 10 μ or longer it will work in a reflecting or refracting mode. For wavelengths below 10 μ, however, the absorption coefficient remains considerably easier to change through the action of the electron beam.

Energy Considerations

Fig. 3 shows the principal elements which will be required to make use of the variation in absorption in a semiconductor, as described above, to construct a practical image-scanning system.

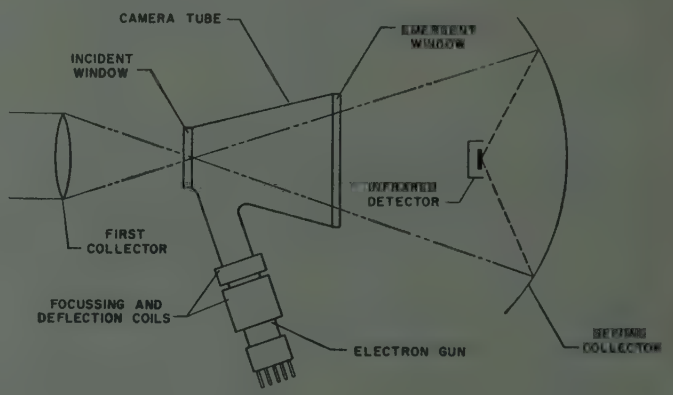

Fig. 3—Scanner tube in the associated optical system.

Assuming the objects in a distant target field of view to be self luminous in the infrared portion of the spectrum, the power P at the filter is given by

$$P = A_T A_c \frac{\eta\gamma T^4}{\pi D^2} (K)$$

Here

γ is the Stefan-Boltzmann constant,
η is the emissivity,
T is the target temperature °K,
K is the appropriate optical transmission factor for the system,
A_T is the area of the target,
A_c is the area of the collector, and
D is the distance to the target.

The electron gun provides a beam of electrons sufficient to form an absorbing or blanking spot of area s on the filter. The area s corresponds to a target area $A_T = sD^2/fl^2$, where fl is the focal length of the first collector. The optical power focussed on the blanking spot is thus

$$P_s = A_c \frac{\eta\gamma T_i^4 s}{\pi fl^2} (K). \qquad (11)$$

Correspondingly, the power on the whole surface of the filter may be written

$$P_F = A_c \frac{\eta\gamma T_\Sigma^4 F}{\pi f l^2} \ (K) \tag{12}$$

where F is the area of the filter and

$$T_\Sigma = \frac{\sum_{i=1}^{n} (T_i)}{n}.$$

T_i and T_Σ have been introduced to indicate that the temperature T_i of an area in the field of view corresponding to the scanning spot may be different from the temperature T_Σ averaged over the total field of view.

In terms of f, the "f number" of the first collector, the expressions (11) and (12) may be written as

$$P_s = \frac{\eta\gamma T_i^4 s}{4f^2} \ (K) \tag{13}$$

$$P_F = \frac{\eta\gamma T_\Sigma^4 F}{4f^2} \ (K) \tag{14}$$

These expressions are valid for f greater than or equal to 1.

Given a suitable second collector, positioned as shown in Fig. 3, the power on the detector will be the total power on the filter minus the small amount absorbed in the area under the blanking spot. Thus $P_D = P_F - P_s$.

P_D represents the power on the infrared detector which comes through the optical system. In addition to this power, consideration must be given to the background power radiated from elements of the optical system and apparatus surrounding the detector. All the radiant energy to which the detector is exposed will be background radiation except for the signal information coming through the silicon filter. In the case in which the detector may receive radiation from a solid angle of 2π steradians, the total power when the beam is off will be

$$P_B = A_D\gamma\left[\eta_B T_B^4 + \frac{\eta_\Sigma T_\Sigma^4 - \eta_B T_B^4}{4f^2} \ (K)\right]. \tag{15}$$

A_D is the detector area and η_B and η_Σ are the average emissivities of the background and the target area, respectively. In the limiting case where η_Σ equals η_B, and T_Σ equals the background temperature T_B, $P_B = A_D(\eta_B\gamma T_B^4)$ as is required thermodynamically.

Were the blanking spot to remain stationary, the detector output signal from the system as so far described would be simply the dc signal corresponding to the detector responsivity times the total power $(P_B - P_s)$. Now, if suitable voltages are applied to the deflection coils, the blanking spot may be made to describe a television-type raster. Under these circumstances, changes in detector output will be proportional to differences in power falling on the detector which correspond to differences in the temperature (or emissivity), of the various portions of the total field of view.

The instantaneous peak-to-peak ac signal power will be

$$\Delta P_s = \frac{\gamma(\eta_i T_i^4 - \eta_j T_j^4)s}{4f^2} \ (K). \tag{16}$$

Thus, we have an elementary system for scanning a field of view. The detector gives an output signal proportional to differences in power radiation from the successively scanned elements i and j of the field of view. If, as outlined in Fig. 4, the detector is connected to a video channel, we may intensity modulate an oscilloscope driven in synchronism with the blanking spot, and reconstruct a visual picture of an infrared source, or sources. This system then is an electronic analog of a mechanical scanning system.

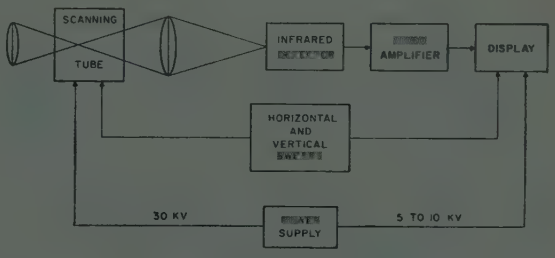

Fig. 4—System block diagram.

The analogy is quite close, but it is worthwhile to point out the significant differences. In (16) the parameter s refers to the electron beam spot area, whereas in a mechanical scanner the term would refer to the area of the detector employed. Since it is easier to obtain a very small electron beam spot than to obtain a very small detector, the present system can provide high resolution more easily than can a mechanical scanner. But as (16) indicates, the signal power is directly proportional to s, so that, as with a mechanical scanner, high resolution is obtained only at the expense of sensitivity.

The need for a second collector in the present system places a restriction on f in (16) which is not present in a mechanical scanner where a second collector is not required. Application of the Abbé sine condition to the second collector shows that to the first order, the minimum value of f is given by $f_{\min} \approx y/2d$, where y is the diameter of the field of the first collector and d is the diameter of the detector employed. In some applications, satisfaction of this relation may limit the useable f number.

A third difference is that, in the present system, the detector is always exposed to radiation from the entire field of view. The signal is obtained by subtracting a small variable amount of energy from this large steady background. The detector of a mechanical scanner is of course exposed to radiation from only one element of the

field of view at any given instant. Possible adverse effects of the large steady background are cell saturation or an increase in system noise due to statistical fluctuations in the background radiation. To determine whether the exposure to the entire field of view is likely to saturate the detector we may compute from (15) at what point the effective background radiation from the target field of view becomes equal to that from the optical apparatus surrounding the detector. Because this system is a double imaging system, and is intended to yield good visual images with flat field and low distortion, it is reasonable to assume that the first collector will not be faster than $f=1$. Under these conditions $4T_B^4=(T_\Sigma^4-T_B^4)$, ignoring optical losses and assuming emissivities of one for convenience. When $T_B=300°\text{K}$, $T_\Sigma=450°\text{K}$. Therefore, if the detector does not saturate upon exposure to room temperature background, it is reasonable to infer that even if the entire field of view were at as high a temperature as 450°K, no saturation would occur. When the field of view is at this temperature, the detector is receiving only twice the usual background power, according to the above calculation.

We may also use the above situation to determine whether the sensitivity of the system will be limited by statistical fluctuations in the background radiation reaching the detector. If we assume a detctor to be sensitive in the wavelength range 0–6 μ, for example, n-type gold doped Ge or InSb,[11] a hemispheric background at 300°K will produce an effective flux density at the detector of 1.8×10^{-3} watts/cm^2. The situation above provides twice this amount, the energy being carried by 30×10^{16} photons/cm^2 seconds. The root-mean-square fluctuation in this number is simply $\sqrt{30\times10^{16}}=5.5\times10^8$, the Bose-Einstein correction being negligible. The root-mean-square fluctuation in energy density is then 2×10^{-11} watts/cm^2.

Thus, the system is not radiation noise limited, unless detectors can be obtained which are sensitive to a flux density of this or a lesser magnitude. At the present time, detectors which are within a factor of 3 of being limited by the radiation noise from a full hemisphere at room temperature, are laboratory curiosities. The above situation, with the entire field of view at 450°K and no care taken to shield the detector from the equipment surrounding it, provides radiation noise only 2.5 times as intense as that from a full hemisphere of room-temperature radiation.

System Performance

The sensitivity of an infrared detector is commonly described in terms of its Noise Equivalent Power, or NEP. The NEP is simply that incident blackbody power just sufficient to make signal equal to noise under the test conditions chosen. The resultant sensitivity is normally reduced to a one-cycle bandwidth and unit signal-to-noise ratio. Hence, if the test blackbody temperature is T_0 we have $\text{NEP}_{T_0}=P/[\sqrt{\Delta B}(V)]$, where ΔB is the bandwidth, V is the signal-to-noise ratio, and P is the blackbody power incident on the detector. Solving this equation for P and converting to peak-to-peak notation, we have

$$P = \text{NEP}_{T_0}\, 2.8\,\sqrt{\Delta B}(V). \tag{17}$$

Using (16) and (17), we may obtain an expression which will allow the prediction of the minimum observable temperature differential in the field of view.

$$(n_i T_i^4 - n_j T_j^4) = \frac{V\ \text{NEP}_{T_0}\, 2.8\sqrt{\Delta B}4f^2}{K\gamma s}. \tag{18}$$

It is necessary to inquire closely into the value of NEP to be used in this equation. As T_i and T_j become appreciably larger than the background temperature, the value of NEP_{T_0} changes accordingly, due to the shift in the spectral distribution of energy at this T_i or T_j. Thus NEP_{T_0} in (18) should be replaced by NEP_{T_1} to indicate improved sensitivity to higher temperature targets. Since NEP_{T_1} is a function of the temperature difference being calculated, graphical or successive approximation methods must be used for accurate solutions of (18) where T_i or $T_j \gg T_B$.

While using ΔB for computation is convenient when NEP values are concerned, from a system point of view the bandwidth must be related to other parameters. It may be shown that the bandwidth required is approximately $\frac{1}{2}$ the number of picture elements transmitted per second to the accuracy required here.[12] If $1/z$ is equal to the number of elements scanned per second, ΔB is equal to $\frac{1}{2}z$ or $b/2\,\mathfrak{F}$ where b is the number of elements per frame and $\mathfrak{F}$ is the frame time in seconds. It is possible therefore to substitute $b^{1/2}/\mathfrak{F}^{1/2}\sqrt{2}$ for $\sqrt{\Delta B}$ in (18). Implied in the wide bandwidth required for transmission of many picture elements per second is the assumption that the detector has a sufficiently short time constant to respond to the highest frequencies.

Derivation of the equations for temperature sensitivity presumed that the scanning spot was completely opaque and that the spot moved "cleanly" from one scanned picture element to the next. As indicated previously, too short a lifetime in the scanned window causes poor blanking, while too long a lifetime may cause smearing. An associated effect, which is not treated explicitly here, arises due to the aperture admittance[13] of the scanned spot. This effect results in a loss of high frequency components of ΔP_s, and in order to maintain maximum S/N ratios the high frequency response of the video amplifier must be correspondingly limited.

[11] M. E. Lasser, P. H. Cholet, and E. C. Wurst, Jr., "High-sensitivity infrared detectors," *J. Opt. Soc. Amer.*, vol. 48, pp. 468–473; July, 1958.

[12] D. G. Fink, "Principles of Television Engineering," McGraw-Hill Book Co., Inc., New York, N. Y., p. 29; 1940.

[13] V. K. Zworykin and G. A. Morton, "Television," John Wiley and Sons, Inc., New York, N. Y., p. 182; 1940.

Experimental Results

In order to check the validity of the foregoing, an experimental version of this scanning system was built. The scanning tube (Filterscan tube No. FTS-100) is shown in Fig. 5 and the laboratory system assembly is shown in Fig. 6. In operation, this system had the following parameters:

Blanking spot area s, 3.1×10^{-4} cm^2;
Raster area A_F, 2.24 cm^2;
Detector area A_D, 0.1 cm^2;
Horizontal sweep, 1 kilocycle;
Vertical sweep, 30 cycles;
Front f number, 3;
Rear f number, 0.75;
System bandwidth, 30 kilocycles.

A beam current of 0.5 milliampere and an anode potential of 25 kv proved sufficient to give complete blanking. The window becomes warm to the touch at this power level. Optical transmission curves for silicon[14] at elevated temperatures indicate however that the window may be operated as hot as 300°C without degrading the performance of the tube, due to thermally-induced free-carrier absorption.

Computation from the sweep rate and raster size gives a frame time $\mathfrak{F}$ of 9×10^{-2} seconds. The calculation of the emissivities η_i was not attempted for the target area. The target was an aluminum hot plate surface, viewed through the aperture plate shown in Fig. 6.

Because some of the available optical elements were not optimized for this application, the resulting system was not capable of maximum performance. The optical path transmission factor K was only 0.3.

An InSb detector (Type 1SC-301) with a 300°K NEP of 1.3×10^{-9} and 500°K NEP of 1.5×10^{-10} was used. When this detector was used with an available transistor preamplifier, the NEP was degraded by a factor of 2. In the experimental test, the hot plate temperature was reduced until a video signal-to-noise ratio of 2 was achieved. This proved sufficient to give a readable picture of the target. The observed temperature difference corresponding to this video signal-to-noise ratio was 125°C.

When the parameters given are put into (20), the predicted observable temperature difference is 133°C. The fact that the observed difference was slightly smaller indicates that small variations from actual values were rounded off. It was of course necessary to use an appropriate NEP; in this case $NEP_{450°K}$ was used as a good approximation to the observed temperature. If $NEP_{300°K}$ had been used, the same computation gives a predicted $\Delta t = 245$°C, illustrating the fact that exact predictions of temperature sensitivity require careful choice of the NEP value to be used in the computation.

Fig. 7 shows the visible image of the target at 125°C above ambient. It appears that the assumptions made in the development of the theory are reasonable and that high-speed electronic scanning of infrared targets may be accomplished in actual practice.

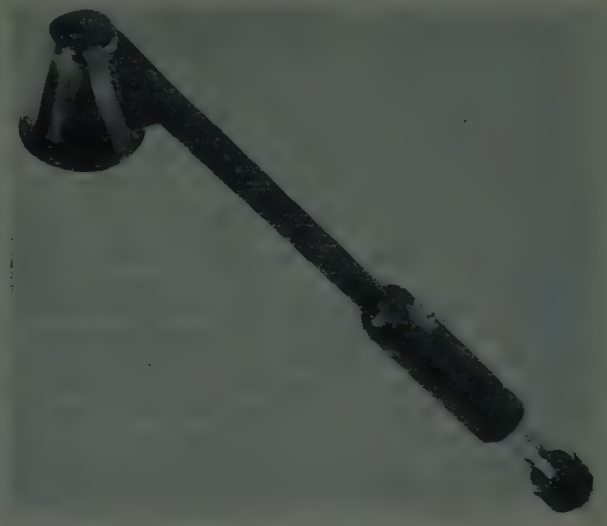

Fig. 5—The scanner tube.

Fig. 6—Laboratory optical assembly.

Fig. 7—Oscilloscope presentation of hot plate as seen through aperture plate. Hot plate temperature = 125°C.

[14] C. M. Phillippi and N. F. Beardsley, Wright Air Dev. Center, Dayton, Ohio, WADC Tech. Note 55-194; December, 1956.

Frequency Multiplication with Nonlinear Capacitors—A Circuit Analysis*

D. B. LEESON† AND S. WEINREB‡

Summary—**This paper presents a circuit analysis of frequency multipliers employing nonlinear capacitors. The analysis applies to the case of a multiplier of any order using semiconductor nonlinear capacitors, and specifies impedance levels, power capabilities, and efficiency in terms of the characteristics of the nonlinear element and the associated linear network. From the formulas derived it is possible to specify the optimum nonlinear characteristic for a given circuit and harmonic number, and to calculate the conditions for maximum efficiency. The procedure is also applicable to frequency dividers, and to frequency multipliers employing nonlinear inductance.**

Introduction

THE POSSIBILITY of efficient frequency multiplication by means of a nonlinear reactance has received considerable attention in recent literature.[1–4] Frequency multiplication with a relatively lossless nonlinear reactance promises efficiencies far in excess of those obtainable with conventional techniques.

Page[5] has shown that the efficiency (power out/power available) for a frequency multiplier employing ideal diodes (nonlinear resistance) is limited to $1/N^2$, where N is the harmonic number of interest. On the other hand, simple energy considerations, supported by the relations of Manley and Rowe,[6] show that all of the power introduced at a single fundamental frequency into a lossless nonlinear reactance must be converted into power at harmonics of the driving frequency.

Thus there exists the theoretical possibility of a lossless frequency multiplier employing nonlinear reactance, and the recently developed high-Q semiconductor nonlinear capacitors provide a promising means of obtaining a relatively lossless nonlinear reactance.

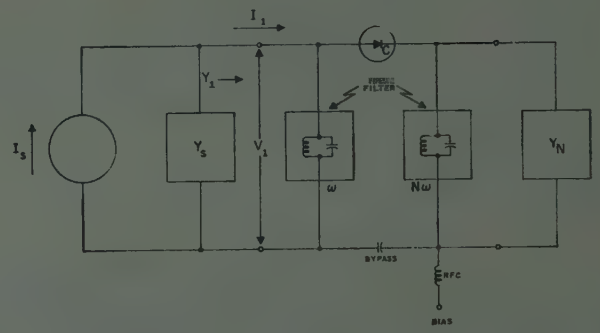

Fig. 1—The "ideal filters" are short circuits at all frequencies except the one specified. The contents of the boxes are merely examples of filters of this type.

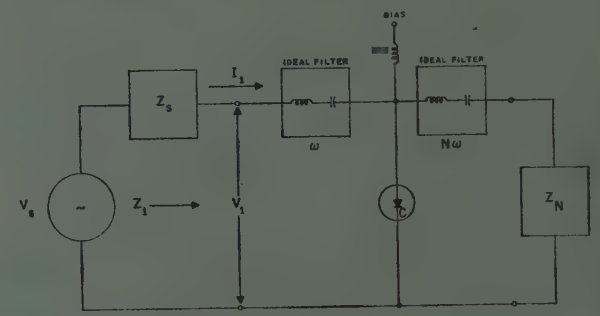

Fig. 2—The "ideal filters" are open circuits at all frequencies except the one specified. The contents of the boxes are merely examples of filters of this type.

Papers on the subject have avoided a circuit analysis, dealing instead with either general energy relations or empirical results. The one exception is a paper by Chang[3] which deals analytically with the problem of losses in some special cases.

It is the purpose of the present paper to provide a basis for design and optimization of frequency multipliers employing nonlinear capacitors. A circuit analysis of such frequency multipliers is presented (the analysis may be adapted to a large class of nonlinear elements). The impedances, efficiency, and other characteristics of the two frequency multiplier circuits of Figs. 1 and 2 are derived as a function of the capacitor characteristics and the circuit operating conditions.

Power Considerations

Power conservation considerations tell us that the efficiency of a frequency multiplier can approach unity if the following conditions can be satisfied:

* Original manuscript received by the IRE, May 11, 1959. This work was supported in part by the U. S. Army (Signal Corps), the U. S. Air Force (Office of Sci. Res., Air Res. and Dev. Command), the U. S. Navy (Office of Naval Research), and the National Science Foundation (Graduate Fellowships).

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[1] A. Uhlir, "The potential of semiconductor diodes in high frequency communications," PROC. IRE, vol. 46, pp. 1099–1115; June, 1958.

[2] M. M. Fortini and J. Vilms, "Solid-state microwave power source," Digest of Technical Papers, 1959 Solid-State Circuits Conference, pp. 82–85; February 12 and 13, 1959.

[3] K. K. N. Chang, "Harmonic generation with nonlinear reactances," *RCA Rev.*, vol. 19, pp. 455–464; September, 1958.

[4] C. H. Page, "Frequency conversion with nonlinear reactance," *J. Res. NBS*, vol. 58, pp. 227–236; May, 1957.

[5] C. H. Page, "Harmonic generation with ideal rectifiers," PROC. IRE, vol. 46, pp. 1738–1740; October, 1958.

[6] J. M. Manley and H. E. Rowe, "Some general properties of nonlinear elements—pt. I, general energy relations," PROC. IRE, vol. 44, pp. 904–913; July, 1956.

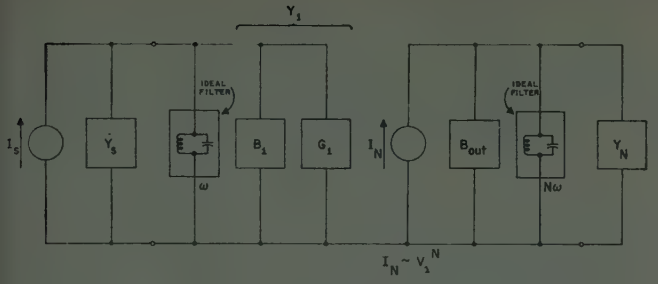

Fig. 3—Model of circuit 1.

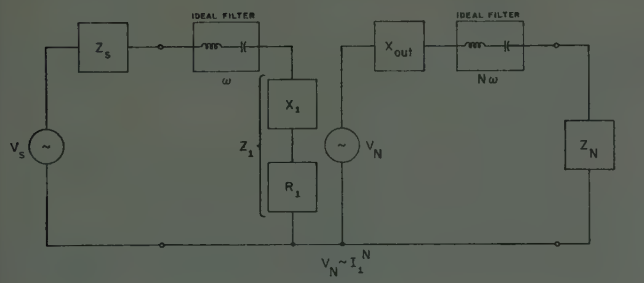

Fig. 4—Model of circuit 2.

1) The nonlinear element and associated linear circuitry are lossless.
2) Power is dissipated in the load only at the desired harmonic frequency; no power is dissipated in the source at any harmonic frequency.
3) The source is conjugate matched at the fundamental frequency.

The analysis will begin assuming that conditions 1 and 2 are met; the consequences of lossy elements and unwanted harmonic dissipation will be considered at a later time. Condition 1 can be met reasonably well with presently available nonlinear capacitors at frequencies below tens of kilomegacycles. Condition 2 can conceivably be met through the use of filters in circuits such as shown in Figs. 1 and 2 (although more sophisticated filters than the simple prototypes shown may be required). The initial concern of this paper will be to state how condition 3 can be met, given ideal filters and reactances, the Q-V (charge vs voltage) characteristics of the nonlinear capacitor, the circuit configuration, the signal level, and the load impedance at the desired harmonic.

Analysis

The analysis derives from Figs. 1 and 2 the circuit models of Figs. 3 and 4, assuming lossless, small-signal operation. The more general case of lossy, large-signal operation will be considered later.

The Q-V relationship of the nonlinear element can be expressed in either of the following two functional forms:

$$Q = Q(V) \tag{1}$$

or

$$V = V(Q). \tag{2}$$

The charge Q can be expressed as

$$Q = Q_0(1 + q) \tag{3}$$

where Q_0 is the dc operating point and q is the normalized ac component of the charge. Similarly, we can let

$$V = V_0(1 + v) \tag{4}$$

where V_0 is the dc operating point, and v is the normalized ac component of voltage. For this analysis, q and v are small with respect to unity.

$Q(V)$ and $V(Q)$ may be approximated in this small-signal case by Taylor series expansions about the zero-signal operating point. Thus,

$$Q(V) = Q_0[1 + \alpha_1 v + \alpha_2 v^2 + \alpha_3 v^3 + \cdots] \tag{5}$$

and

$$V(Q) = V_0[1 + \beta_1 q + \beta_2 q^2 + \beta_3 q^3 + \cdots] \tag{6}$$

where

$$\alpha_k = \frac{V_0{}^k}{Q_0 k!} \frac{d^k Q}{dV^k}\bigg|_{V=V_0} \tag{7}$$

and

$$\beta_k = \frac{Q_0{}^k}{V_0 k!} \frac{d^k V}{dQ^k}\bigg|_{Q=Q_0}. \tag{8}$$

Eqs. (3)–(6) can be combined to yield the relations

$$q = \sum_{k=1}^{\infty} \alpha_k v^k \tag{9}$$

and

$$v = \sum_{k=1}^{\infty} \beta_k q^k. \tag{10}$$

These are the general relations of normalized ac charge and voltage in the nonlinear element. Current is determined by taking the time derivative of charge.

Let us make use of (9) to obtain the charge on the nonlinear element in terms of the voltage; a dual analysis employs (10) to solve for the voltage in terms of the charge.

The normalized ac variables will be represented throughout by their complex Fourier series

$$q = \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} q_n \epsilon^{jn\omega t}; \quad i = \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} i_n \epsilon^{jn\omega t} = \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} jn\omega q_n \epsilon^{jn\omega t};$$

$$v = \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} v_n \epsilon^{jn\omega t} \tag{11}$$

where ω is the fundamental driving radian frequency.

In these series $v_{-n}=v_n^*$ and $q_{-n}=q_n^*$ because the actual voltages and charges are real physical quantities. Further, it should be remembered that if one of the variables were to be put in the trigonometric form $v=v_{\text{trig}}\cos(n\omega t+\lambda)$, then $|v_{\text{trig}}|=|v_n|+|v_{-n}|=2|v_n|$.

The quantities v^k appearing in (9) can be represented by their respective complex Fourier series in the following manner:

$$v^2=\sum_{n=-\infty}^{\infty}(v^2)_n\epsilon^{jn\omega t}\quad\text{where}\quad(v^2)_n=\sum_{\substack{j,l=-\infty\\ j+l=n}}^{\infty}v_jv_l$$

$$v^3=\sum_{n=-\infty}^{\infty}(v^3)_n\epsilon^{jn\omega t}\quad\text{where}\quad(v^3)_n=\sum_{\substack{j,l,m=-\infty\\ j+l+m=n}}^{\infty}v_jv_lv_m,\qquad(12)$$

and so on. Note that all possible permutations must be considered in the calculation of one of the Fourier coefficients. $(v^k)_n$ is the sum of all combinations of products of k voltages whose indices add up to n.

We insert these series for v^k into (9), and by equating terms of equal frequency we can find q_n, given all of the v_n. In the general case the process is prohibitively complicated, but there are some simplifications which can be made in the case of a frequency multiplier of order N.

Eq. (9) is solved by allowing only fundamental and Nth harmonic voltage to be present ($v_{\pm1}$, $v_{\pm N}\neq0$, all others zero as is the case in Fig. 1) in a frequency multiplier of order N. This allows us to calculate the value of $(v^k)_n$ in terms of $v_{\pm1}$ and $v_{\pm N}$ only; with the introduction of the load constraint, $i_N=jN\omega q_N=-v_Ny_N$ (where y_N is the normalized load admittance at the Nth harmonic) we can then calculate q_1 and q_N in terms of v_1, which is the immediate object of the analysis. Note that we are not interested in any other frequency components of q; further, we are not interested in q_{-1} and q_{-N} since these are simply the complex conjugates of the quantities of interest.

If we choose to specify charge rather than voltage as the independent variable, we then employ a similar procedure to solve (10). Eq. (10) is solved in the same manner as (9), except that now we limit the possible frequencies for q rather than v, use the load constraint $v_N=-i_Nz_N=-jN\omega q_Nz_N$ (where z_N is the normalized load impedance at the Nth harmonic), and substitute the series expansions for q^k (which are the dual of those for v^k) into (10) to solve for v_1 and v_N in terms of q_1. This analysis pertains to Fig. 2.

Any nonlinear element whose characteristics can be put in the form of (9) or (10) can be treated in the manner of this analysis.

Small-Signal Approximations

One last important simplification is necessary before the solution may be readily obtained. If we follow the procedure outlined in the previous section we get an expression for q_N, which is of the form

$$q_N=\alpha_1v_N+\alpha_2\sum_{\substack{j+l=N\\ |j|,|l|=1\text{ or }N}}v_jv_l+\alpha_3\sum_{\substack{j+l+m=N\\ |j|,|l|,|m|=1\text{ or }N}}v_jv_lv_m+\cdots.\qquad(13)$$

We can now show that, for the small-signal case, only the first and Nth terms of (13) need be considered.

Consider the summations in each term of (13). Since the only voltages present are $v_{\pm1}$ and $v_{\pm N}$, these summations contain only terms of the following two types:

1) $v_N\{(v_1v_{-1})^a(v_Nv_{-N})^b(v_Nv_{-1}{}^N)^c(v_{-N}v_1{}^N)^d\}$

where a, b, c, d are positive integers or zero and $2a+2b+(N+1)c+(N+1)d+1=k$. Note that c and d are zero here for $k<N+2$.

2) $v_1{}^N\{(v_1v_{-1})^a(v_Nv_{-N})^b(v_Nv_{-1}{}^N)^c(v_{-N}v_1{}^N)^d\}$

where a, b, c, d are positive integers or zero (not necessarily the same as above) and $2a+2b+(N+1)c+(N+1)d+N=k$. Note that here c and d are zero for $k<2N+2$.

The quantities (v_1v_{-1}), (v_Nv_{-N}), and α_k are positive real. Inspection will reveal that all coefficients of v_N for $k<N+2$ are positive real, and all coefficients of $v_1{}^N$ for $k<2N+2$ are positive real. We can write (13) in the form

$$q_N=Av_N+Bv_1{}^N\qquad(14a)$$

where we have neglected higher order ($k>N+2$ for A, $k>2N+2$ for B) contributions to A and B; thus, they are positive real quantities.

The current ($i_N=jN\omega q_N$) due to the first term of (14a) is in quadrature with v_N. This means that this term does not contribute to the exchange of power at the Nth harmonic frequency; rather, it represents a reactance. The second term, on the other hand, represents an independent current source; it is this term which accounts for the power transferred to the Nth harmonic.

In a small-signal analysis we need consider only the lowest order contribution to the factors A and B. Thus the "reactive" term becomes α_1v_N, which is the first term of the Taylor series (9). The largest term of the "generator" type results from the Nth term of the Taylor series (9), and is the quantity $\alpha_Nv_1{}^N$. The remaining portions of the factors A and B are composed of quantities which are of higher order in the small-signal variables; in a small-signal analysis these may be neglected.

In the dual case where we specify the charges and solve for the voltages, a similar argument applies. Thus we conclude that only the first and Nth terms of the appropriate Taylor series (9) or (10) need be considered in the case of a frequency multiplier of order N.

Using this simplification we can reduce the first and Nth frequency components of (9) and (10) to a small number of terms, and can complete the analysis.

Circuit Equations

Let us solve first the case for which (9) is appropriate. This case, which corresponds to Figs. 1 and 3, involves the solution for the various charges in terms of the driving voltage v_1.

For this case, (9) is simplified to

$$q = \alpha_1 v + \alpha_N v^N. \tag{14b}$$

The term v^N is replaced by its complex Fourier series (12).

The two frequency components of (14) which are of interest are

$$q_1 = \alpha_1 v_1 + \alpha_N (v^N)_1 \tag{15}$$

and

$$q_N = \alpha_1 v_N + \alpha_N (v^N)_N. \tag{16}$$

Separating (15) and (16) into real and imaginary parts and making small-signal approximations, we obtain the four equations which arise from (14). We let $v_1 = v_{-1}$ for convenience; this amounts to specifying the heretofore arbitrary time origin. There is no loss of generality by specifying v_1 real.

$$q_{1_r} = \alpha_1 v_1 \tag{17}$$

$$q_{1_i} = N\alpha_N v_1^{N-1} v_{N_i} \tag{18}$$

$$q_{N_r} = \alpha_1 v_{N_r} + \alpha_N v_1^N \tag{19}$$

$$q_{N_i} = \alpha_1 v_{N_i}. \tag{20}$$

The subscripts r and i signify real and imaginary components, respectively

Expanding the load constraint $q_N = -v_N y_N / jN\omega$ into real and imaginary parts yields

$$q_{N_r} = -\frac{1}{N\omega}\left[b_N v_{N_r} + g_N v_{N_i}\right] \tag{21}$$

$$q_{N_i} = \frac{1}{N\omega}\left[g_N v_{N_r} - b_N v_{N_i}\right] \tag{22}$$

where g_N and b_N are the components of y_N, the load admittance.

We can solve (19)–(22) for v_{N_i} which appears in (18)

$$v_{N_i} = -\alpha_N v_1^N \left\{ \frac{\frac{g_N}{N\omega}}{\left(\frac{g_N}{N\omega}\right)^2 + \left(\alpha_1 + \frac{b_N}{N\omega}\right)^2} \right\}. \tag{23}$$

At this point it is possible to calculate the input admittance of the model of Fig. 3. The normalized admittance is

$$y_1 = \frac{i_1}{v_1} = \frac{j\omega q_1}{v_1} = \frac{-\omega q_{1_i}}{v_1} + \frac{j\omega q_{1_r}}{v_1}$$

$$= N\omega\alpha_N{}^2 v_1^{(2N-2)} \left\{ \frac{\frac{g_N}{N\omega}}{\left(\frac{g_N}{N\omega}\right)^2 + \left(\alpha_1 + \frac{b_N}{N\omega}\right)^2} \right\} + j\omega\alpha_1. \tag{24}$$

If the output is resonated (*i.e.*, if $\alpha_1 + b_N/N\omega = 0$), then the input conductance is the simpler form

$$g_1 = \frac{N^2\omega^2}{g_N} \alpha_N{}^2 v_1^{(2N-2)}. \tag{25}$$

Eqs. (24) and (25) are normalized expressions for the input parameters of the equivalent circuit of Fig. 3.

In the case corresponding to Figs. 2 and 4, (10) is appropriate. Here we solve for the various voltages in terms of the driving charge q_1.

For this case (10) becomes

$$v = \beta_1 q + \beta_N q^N \tag{26}$$

where the term

$$q^N = \sum_{n=-\infty}^{\infty} (q^N)_n e^{jn\omega t}; \quad (q^N)_n$$

is evaluated as in (12).

The two frequency components of (26) which are of interest are

$$v_1 = \beta_1 q_1 + \beta_N (q^N)_1 \tag{27}$$

$$v_N = \beta_1 q_N + \beta_N (q^N)_N. \tag{28}$$

We can let $q_1 = q_{-1}$ (q_1 = real) without any loss of generality. Separating (27) and (28) into real and imaginary parts and making small-signal approximations we obtain

$$v_{1_r} = \beta_1 q_1 \tag{29}$$

$$v_{1_i} = N\beta_N q_1^{N-1} q_{N_i} \tag{30}$$

$$v_{N_r} = \beta_1 q_{N_r} + \beta_N q_1^N \tag{31}$$

$$v_{N_i} = \beta_1 q_{N_i}. \tag{32}$$

The load constraint, $v_N = -i_N z_N = -jN\omega q_N z_N$, is expanded into real and imaginary parts to yield

$$v_{N_r} = N\omega(x_N q_{N_r} + r_N q_{N_i}) \tag{33}$$

$$v_{N_i} = -N\omega(r_N q_{N_r} - x_N q_{N_i}) \tag{34}$$

where r_N and x_N are the components of z_N.

We can solve (31)–(34) for q_{N_1} which appears in (30):

$$q_{N_i} = \beta_N q_1^N \left\{ \frac{N\omega r_N}{(N\omega r_N)^2 + (\beta_1 - N\omega x_N)^2} \right\}. \tag{35}$$

Here it is possible to calculate the input impedance of the model of Fig. 4. The normalized impedance is

$$z_1 = \frac{v_1}{i_1} = \frac{-jv_1}{\omega q_1} = \frac{v_{1_i}}{\omega q_1} - j\frac{v_{1_r}}{\omega q_1}$$

$$= \frac{N\beta_N{}^2 q_1^{2N-2}}{\omega} \left\{ \frac{N\omega r_N}{(N\omega r_N)^2 + (\beta_1 - N\omega x_N)^2} \right\} - j\frac{\beta_1}{\omega}. \tag{36}$$

If the output is resonated (*i.e.*, if $\beta_1 = N\omega x_N$), then the input resistance becomes

$$r_1 = \frac{\beta_N{}^2}{\omega^2 r_N} q_1^{2N-2} = \frac{\beta_N{}^2}{\omega^{2N} r_N} i_1^{2N-2}. \tag{37}$$

If the reactive term of (36) is canceled by series tuning, and the output circuit is resonated as in (37), then the conditions of Fig. 5 apply, and we can write the input resistance as a function of v_1 rather than i_1. Using the fact that $v_1 = i_1 r_1$, and substituting, we have

$$r_1 = \frac{1}{\omega}\left(\frac{\beta_N^2}{r_N \omega}\right)^{1/(2N-1)} (v_1)^{(2N-2)/(2N-1)}. \tag{38}$$

These last three expressions are normalized expressions for the input parameters of the equivalent circuit of Fig. 4.

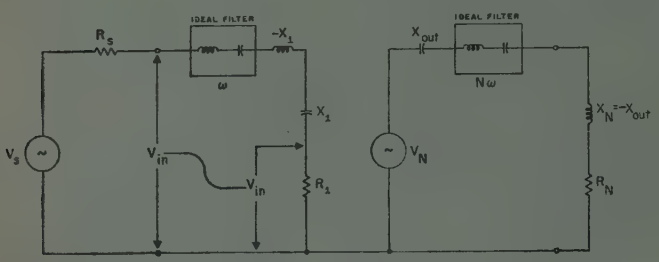

Fig. 5—Equivalent circuit at resonance. The additional elements $-x_1$ and $-x_{out}$ result in resonance.

Semiconductor Nonlinear Capacitor

Let us now see how this generalized, normalized analysis applies to the case of a frequency multiplier employing a semiconductor nonlinear capacitor (varactor). The small-signal capcitance of the element is taken to be

$$C(V) = \frac{dQ}{dV} = \frac{C_1}{(V+\phi)^\gamma} \tag{39}$$

where V is the terminal voltage, ϕ is the "contact potential" of the junction, C_1 is the value of the capacitance for $(V+\phi)=1$ volt (C_1 has units of farad-volt$^\gamma$), and $0<\gamma<1$.

Integrating this gives the Q-V characteristics of the element

$$Q = \frac{C_1}{1-\gamma}(V+\phi)^{1-\gamma} \tag{40}$$

where the constant of integration has been absorbed in Q.

Separating the variables into static and ac components, $Q = Q_0 + Q_{ac}$ and $V+\phi = V_0 + V_{ac}$, and setting the ac components equal to zero, we have the following relation between the dc operating points:

$$Q_0 = \frac{C_1 V_0^{1-\gamma}}{1-\gamma} \equiv \frac{C_0 V_0}{1-\gamma}. \tag{41}$$

V_0 is the total bias voltage (terminal voltage plus contact potential), and $C_0 = C_1/V^\gamma$, which is the capacitance of the element at bias voltage V_0.

Note that if V_{ac} should exceed V_0, the diode forming the capacitor would conduct over part of the period. Should this occur, the circuit would presumably be subject to the limitations set forth by Page[5]; at any rate the mode of operation changes, and the device is no longer used purely as a high-Q capacitor. Thus, for operation in the capacitive mode analyzed here, V_{ac} cannot exceed V_0.

The Taylor series coefficients (7) and (8) are

$$\alpha_k = \frac{1}{k!}\{[(1-\gamma)][(1-\gamma)-1][(1-\gamma)-2] \cdots [(1-\gamma)-k+1]\} \tag{42}$$

and

$$\beta_k = \frac{1}{k!}\left\{\left[\left(\frac{1}{1-\gamma}\right)\right]\left[\left(\frac{1}{1-\gamma}\right)-1\right]\left[\left(\frac{1}{1-\gamma}\right)-2\right] \cdots \left[\left(\frac{1}{1-\gamma}\right)-k+1\right]\right\} \tag{43}$$

for this case. These can be put in gamma function form if convenient.

We can now "un-normalize" the expressions obtained earlier for the input parameters of the equivalent circuits. We use the following relationships:

$$v_n = \frac{V_n}{V_0}$$

$$q_n = \frac{Q_n}{Q_0} = \frac{Q_n(1-\gamma)}{C_0 V_0} = \frac{I_n(1-\gamma)}{\omega C_0 V_0}$$

$$|V_{in}| = 2|V_1|; \qquad |I_{in}| = 2|I_1|$$

$$z_n = \frac{v_n}{i_n} = \frac{C_0}{1-\gamma} Z_n; \qquad y_n = \frac{1-\gamma}{C_0} Y_N$$

where upper case letters indicate actual quantities and lower case letters are normalized quantities. V_{in} and I_{in} are the peak values of the input voltage and current.

The input admittance of Fig. 1, (24), becomes

$$Y_1 = \omega C_0 \frac{N^2 \alpha_N^2}{(1-\gamma)^2 2^{2N-2}}\left(\frac{V_{in}}{V_0}\right)^{2N-2} \cdot \left\{\frac{\frac{G_N}{N\omega C_0}}{\left(\frac{G_N}{N\omega C_0}\right)^2 + \left(1+\frac{B_N}{N\omega C_0}\right)^2}\right\} + j\omega C_0. \tag{44}$$

If the output circuit is resonated, we have, from (25)

$$G_1 = \omega C_0 \frac{\alpha_N^2 N^2}{(1-\gamma)^2 2^{2N-2}}\left(\frac{V_{in}}{V_0}\right)^{2N-2}\left(\frac{\omega C_0}{G_N}\right). \tag{45}$$

The input impedance of Fig. 2, (36), becomes

$$Z_1 = \frac{1}{\omega C_0}\frac{N\beta_N^2(1-\gamma)^{2N}}{2^{2N-2}}\left(\frac{I_{in}}{\omega C_0 V_0}\right)^{2N-2} \cdot \left\{\frac{N\omega C_0 R_N}{(N\omega C_0 R_N)^2 + (1-N\omega C_0 x_N)^2}\right\} - j\frac{1}{\omega C_0}. \tag{46}$$

For the case of resonant output, we have

$$R_1 = \frac{1}{\omega C_0} \frac{\beta_N^2(1-\gamma)^{2N}}{2^{2N-2}} \left(\frac{I_{in}}{\omega C_0 V_0}\right)^{2N-2} \frac{1}{\omega C_0 R_N}. \quad (47)$$

In the special case of series resonant input and output, the input resistance of Fig. 2 is

$$R_1 = \frac{1}{\omega C_0} \frac{(1-\gamma)[(1-\gamma)\beta_N^2]^{1/(2N-1)}}{2^{(2N-2)/(2N-1)}} \cdot \left(\frac{V_{in}}{V_0}\right)^{(2N-2)/(2N-1)} \left(\frac{1}{\omega C_0 R_N}\right)^{1/(2N-1)}. \quad (48)$$

Note that these contain information about the nonlinear element (γ, α, β, C_0), the signal and bias level (V_{in}/V_0, I_{in}/V_0), and the external circuit and load (R_N, X_N, G_N, B_N). Note that $1/\omega C_0$ is the no-signal reactance at the fundamental frequency of the nonlinear capacitor.

A case of particular interest is that of the frequency doubler. In this case (45) becomes

$$G_1 = \omega C_0 \frac{\gamma^2}{4} \left(\frac{V_{in}}{V_0}\right)^2 \left(\frac{\omega C_0}{G_2}\right) \quad (49)$$

and (48) becomes

$$R_1 = \frac{1}{\omega C_0} \left(\frac{\gamma}{4}\right)^{2/3} \left(\frac{V_{in}}{V_0}\right)^{2/3} \left(\frac{1}{\omega C_0 R_2}\right)^{1/3}. \quad (50)$$

These equations may be employed to design a frequency doubler of the type of Fig. 1 or Fig. 2.

Large-Signal Validity

It is reasonable to inquire whether the analysis is valid in the large-signal case. In order to aid the thinking of the reader on the point of signal magnitude, it should be mentioned again that the signal voltage cannot exceed the total bias voltage, V_0, if operation in a purely capacitive mode is to be maintained, *i.e.*, if conduction is to be prevented. Since the magnitudes of the complex Fourier coefficients are equal to one-half the magnitudes of the actual voltages, the normalized voltage coefficients cannot exceed one-half.

Inspection of the various assumptions and approximations made in the analysis will show that for v_1 and v_N of magnitude one-quarter, for example, all of the approximations are extremely good. It is reasonable to expect that there should be no appreciable error involved in applying the small-signal results at any signal level likely to be encountered in frequency multipliers employing semiconductor nonlinear capacitors in a purely capacitive mode.

Experimental data will be seen to support this conclusion. Even with the junction on the verge of conduction, it is felt that the relationships derived in the earlier sections will certainly serve to indicate the order of magnitude of impedance or admittance one could expect in a given application.

Losses

We come now to the question of losses. As mentioned previously, losses can arise from one of two sources. There are 1) resistive losses in the nonlinear element and its associated filters, and 2) losses in the source and load at unwanted frequencies.

Let us first treat losses due to non-ideal elements. The equivalent circuit of Fig. 6 will apply. The losses will be calculated for one circuit configuration, and the losses for the other are simply derived from the dual analysis.

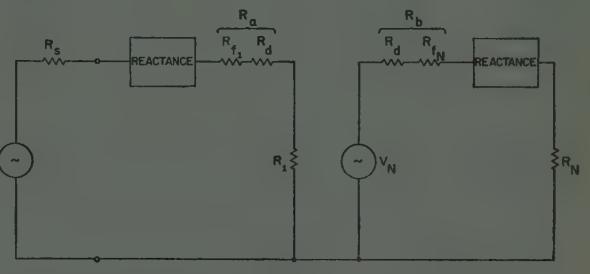

Fig. 6—Equivalent circuit for losses.

R_a, the resistance appearing in the input circuit (in addition to R_1), is the sum of the filter series equivalent resistance, R_{f_1}, and the diode equivalent series resistance, R_d. Any shunt losses in the diode must be transformed to their series equivalent.

The power dissipated in the actual equivalent input resistance R_1 is P_1, and the input power to the whole circuit is P_{in}.

From simple circuit relations

$$\frac{P_{in}}{P_1} = 1 + \frac{R_a}{R_1}. \quad (51)$$

Similarly, on the output side,

$$\frac{P_1}{P_N} = 1 + \frac{R_b}{R_N} \quad (52)$$

where R_b represents the losses on the output side of the circuit. P_N is the power at the Nth harmonic reaching the load.

Combining the two relations, we obtain

$$\frac{P_{in}}{P_N} = \left(1 + \frac{R_a}{R_1}\right)\left(1 + \frac{R_b}{R_N}\right). \quad (53)$$

In calculating the value of R_1 in the lossy case, we must include R_b in the load resistance at the Nth harmonic. If the filters used are good enough so that all other frequency components may be neglected, then (53) may be used to calculate the efficiency to be expected in the frequency multiplier.

In the dual case, the same calculation can be made using G_1, G_N, G_a, and G_b.

The other source of loss—dissipation at unwanted frequencies—may be made negligible in some cases by

the use of appropriate realizable filters. If loss of this second type must be considered, it may be calculated by the following procedure.

The load impedance at the unwanted harmonic(s) may be calculated or measured. This impedance is then used to calculate the equivalent input resistance or conductance of the multiplier, assuming it to be operating only to the unwanted harmonic under consideration. This additional loss may then be included in R_a or G_a (since even in a nonlinear circuit we may add real power and can indicate the total loss by a resistance or conductance). The additional losses due to dissipation at harmonics other than the desired one may thus be taken into account approximately.

Experimental Verification

Experimental verification of the relationships derived has been carried out with the circuits shown in Figs. 7 and 8. The data obtained with frequency doublers are presented in Figs. 9 and 10.

In the case of Fig. 9, which corresponds to the circuit of Fig. 7, no input filter was employed, as the bridge had a very low impedance at all frequencies. The input admittance of the frequency multiplier was measured as a function of the output resistance and the signal level. The efficiency in this case was calculated from the voltage and admittance measurements obtained, and the power gain G_p was of the order of -0.7 db. The curve "corrected for loss" includes fundamental loss, G_{loss_1}, in parallel with R_1.

Fig. 10 is a plot of input resistance vs signal level for the circuit of Fig. 8. The calculated resistance is derived from (50), including R_b in the output resistance and adding R_a to the input resistance calculated. R_a and R_b were measured and found to be approximately 22 ohms for the particular circuit. The efficiency was calculated to be -1.1 db and the measurements corroborated this

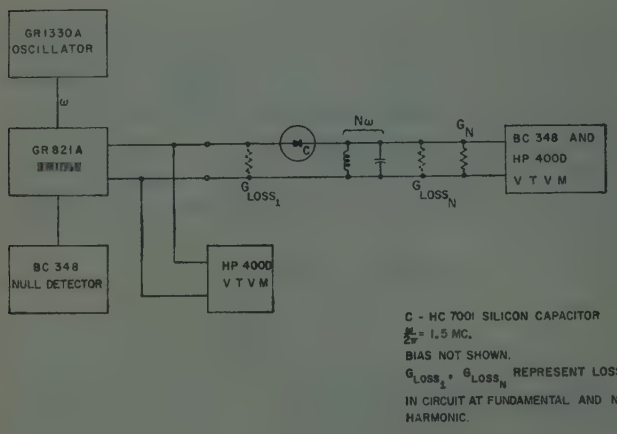

Fig. 7.

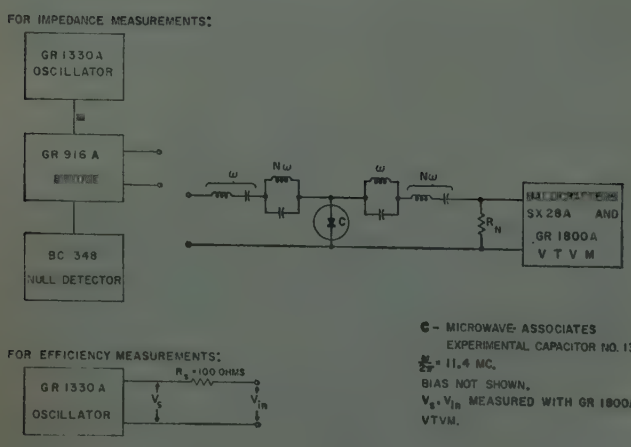

Fig. 8.

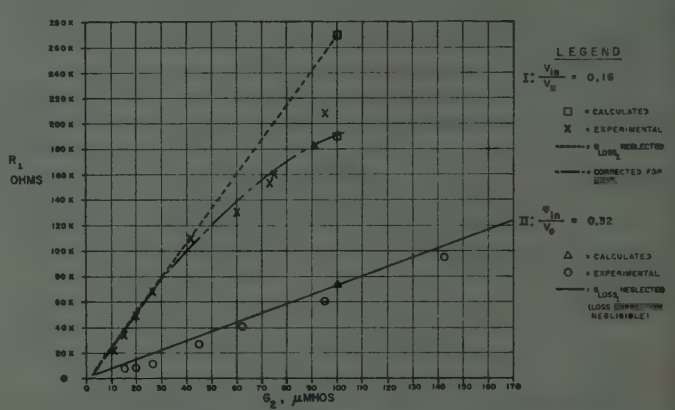

Fig. 9—Input resistance of Fig. 7 vs output conductance.

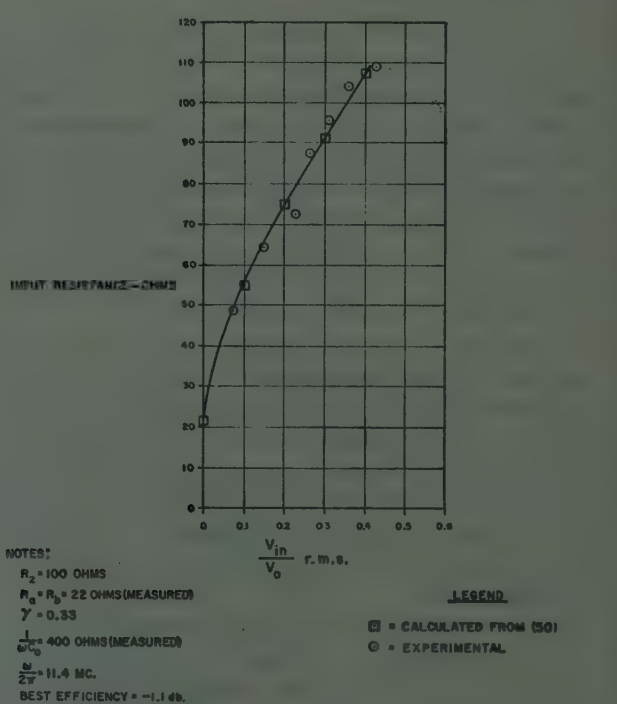

Fig. 10—Input resistance of Fig. 8 vs signal level.

figure (this efficiency is transducer gain or power out divided by power available from the source).

This experimental work was performed at low frequencies to facilitate both construction and measurement.

Conclusions

The circuit equations and impedance relationships derived should help to clear the picture of frequency multiplication with nonlinear reactance. They can be used in the design of frequency multipliers at any frequency and, presumably, of any order.

A few thoughts about maximizing efficiency of a given circuit are now in order. Let us consider the circuit of Fig. 2; our remarks will apply in dual form to that of Fig. 1. The maximum efficiency occurs when R_1 and R_N are large with respect to the equivalent loss resistances R_a and R_b (see Fig. 6). Generally, one would not choose R_N such that losses in the output circuit are intentionally high. Given a reasonable R_N, the problem is attaining a suitably large R_1. Inspection of the formulas for R_1 will reveal that this is not always possible; in particular, it is difficult for very small signal levels, and it is difficult if the appropriate Taylor series coefficient, α or β, is small. Further, it becomes increasingly difficult with increasing N; that is, with increasing multiplication order.

From the expressions for R_1 we conclude that it is generally desirable to operate with a signal fairly large with respect to the bias voltage (although not exceeding it, of course).

Considering the fact that a large Nth Taylor series coefficient is desirable, one may determine what type of nonlinearity is best for a given application. A Q-V relationship which provides the largest possible Nth Taylor coefficient is optimum from the standpoint of efficiency in a practical circuit.

It may also be determined that certain harmonics may not be obtained with particular characteristics and circuit configurations. For example, a capacitance of the form $C=C_1/(V+\phi)^{1/2}$ will generate no harmonics higher than the second in the circuit of Fig. 2 since all of the higher order Taylor coefficients are zero.

From the impedance equations it is also clear that R_1 is maximized for the condition of the output circuit resonant. This condition is particularly convenient to implement since it is desirable to resonate the load with the capacitance of the nonlinear element in order to form the required output filter.

The case of very high order frequency multiplication is interesting to consider. Considerable difficulty has been experienced in constructing efficient multipliers of order 100, for example. The efficiencies reported,[7] although they represent a material improvement in the state of the art, are not significantly different from the Page limitation of $1/N^2$ (40 db for $N=100$). This endeavor is hampered, of course, by filter limitations.

Considering again the circuit of Fig. 2, we see that for high order multiplication the product of R_1 and R_N becomes quite small. This means that for a reasonable R_N one must suffer an $R_1 \ll R_a$, with the resulting severe losses (or if R_1 is reasonable, then $R_N \ll R_b$). Note that the minimum value of load seen by the circuit is R_b; that is, in the lossy case we must include R_b in the load resistance for the purposes of calculating R_1.

Some calculations based on an input and output filter Q of 50 (unloaded, but including varactor Q), optimum source and load $\gamma=\frac{1}{2}$, and input and output resonant yield the data presented in Fig. 11. Note that for higher order multipliers the nonlinear resistive mode may be more efficient than the capacitive mode; the efficiency of the capacitive mode in this circuit environment drops approximately 6 db per *harmonic* rather than 6 db per *octave*. It is the feeling of the authors that the explanation for the lower-than-expected efficiencies reported in higher-order multipliers (it had been hoped by some that the efficiency of a higher-order reactive multiplier might approach unity) may be that in these practical, lossy situations the capacitive effect does not predominate over the "diode" effect. The presence of nonlinear reactance may enhance the efficiency, but it seems that higher-order multipliers presently constructed operate predominantly in the nonlinear resistive, or switching, mode. It would appear unwarranted

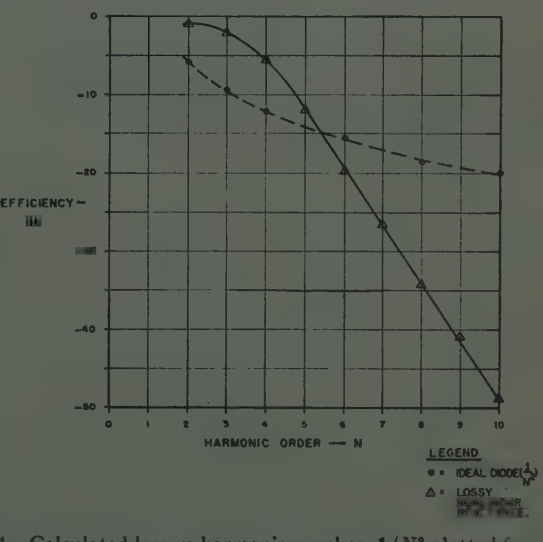

Fig. 11—Calculated loss vs harmonic number. $1/N^2$ plotted for comparison. The optimum efficiency for a typical lossy semiconductor nonlinear capacitor frequency multiplier is compared with the efficiency of a *lossless* ideal rectifier. The optimum efficiency has been calculated for the case of an abrupt junction nonlinear capacitor, $V_1/V_0=\frac{1}{2}$, input and output unloaded $Q=50$, and the circuit of Fig. 1.

[7] C. L. Searle, M.I.T., Cambridge, Mass., D. R. Holcomb, Hughes Aircraft Co., Culver City, Calif., and others, private communication; April 15, 1959.

to expect higher-order multiplier efficiencies greatly in excess of the Page ideal-diode limitation.

Note, however, that the equations and relations in this paper allow one to design quite good doublers, triplers, and other lower order multipliers (the filter requirements are much less stringent in these cases). It is not unreasonable to assume that six of the doublers of Fig. 8 could be cascaded to give a multiplication of 64 with a loss of some 6 or 7 db. This method may well prove superior to a single multiplier of high order, despite a rather higher complexity and component count.

The maximum power which can be handled may be limited by one of two factors. These are: the voltage across the nonlinear capacitor cannot exceed the total bias voltage or breakdown voltage, and the I^2R losses in the varactor must remain below a certain minimum. In general, the power which can be handled by the frequency multiplier is greater for lower impedance circuits. The configuration of Fig. 2 has the advantage in this respect. The doubler of Fig. 8 has been capable of handling several hundred milliwatts without reduced efficiency.

As pointed out earlier, the circuit equations apply equally well to frequency dividers. With an interchange of source and load constraints, the divider circuit may be described.

ACKNOWLEDGMENT

The authors wish to acknowledge the support of Prof. C. L. Searle who supervised the research. The valuable comments of Prof. S. J. Mason, Prof. W. M. Siebert and R. P. Rafuse were also greatly appreciated.

CORRECTION

The following correction should be noted in "IRE Standards on Navigation Aids: Direction Finder Measurements, 1959," which appeared on pages 1349–1371 of the August, 1959, issue of PROCEEDINGS.

Section 1.1.4.6, page 1358. The equation in this Section should be as follows:

$$\text{Pick Up Factor (Meters)} = \frac{\left[\text{Field Strength of Section 1.1.4.5}\right]\left[\frac{\text{Effective Height of Dipole of Section 1.1.4.6}}{2}\right]\left[1 - \frac{R_{\text{series}} \text{ of Section 1.1.4.4}}{\text{Dipole Cable Impedance}}\right]}{\text{Field Strength of Section 1.1.4.1}}$$

Operating Characteristics of an Ammonia Beam Maser*

FRANK S. BARNES†

Summary—**This paper describes the operating characteristics of an ammonia beam maser. The simple theory for the operation is expanded to predict the angular distribution of the molecules coming from the beam collimator and the effect of the focuser on the velocity distribution of the molecules entering the cavity.**

Experimental results for the operation of the cavity in the TM_{011} and TM_{013} mode show the effects of the variation in beam current and cavity tuning on the frequency and amplitude of oscillation. Relating these results to the theory with the help of measurements of the beam flux density demonstrates the importance of molecular collisions and the beam divergence. Three methods of locating line center are examined, and it is shown that the line centers obtained in each case may be varied over a range of at least 5 parts in 10^8 by changing the operating parameters.

Introduction

THE ammonia beam oscillator is the first of a new group of devices which makes use of the internal energy of a molecule as a source of microwave power. In this device, a beam of ammonia molecules travels through a large inhomogeneous focusing field to a cavity which is resonant at the transition frequency of a molecule. The focusing field separates the molecules so that more molecules in high energy levels than in low energy levels enter the cavity. Therefore, more molecules radiate than absorb energy, and the beam becomes a source of microwave power.

The sharpness and reproducibility of the molecular energy levels make the coherent radiation in the maser cavity a useful source of microwave power for a very stable oscillator. Recently, short term stabilities of about 2 parts in 10^{12} have been measured at the Watson Laboratories [16] and long term stabilities of better than 2 parts in 10^{11} have been measured at the National Bureau of Standards [33] for periods of six hours.

The first operating maser was constructed by Townes and his associates at Columbia University in 1954 [23], [24]. Shortly after this, Helmer, at Stanford [25a], constructed the two masers on which the measurements described in this paper were made. The objectives of the present study were to examine the characteristic of the beam and to compare several methods of establishing a line center.

Description of the Maser Oscillator

The two Stanford masers with auxiliary equipment are shown in Fig. 1. There are essentially four parts to an ammonia beam oscillator:

1) an ammonia beam-forming device called the *effuser* or *beam collimator*,
2) an energy-state separator or *focuser*,
3) a resonant cavity,
4) a vacuum pump to remove the excess ammonia from the vicinity of the resonant cavity and the focuser.

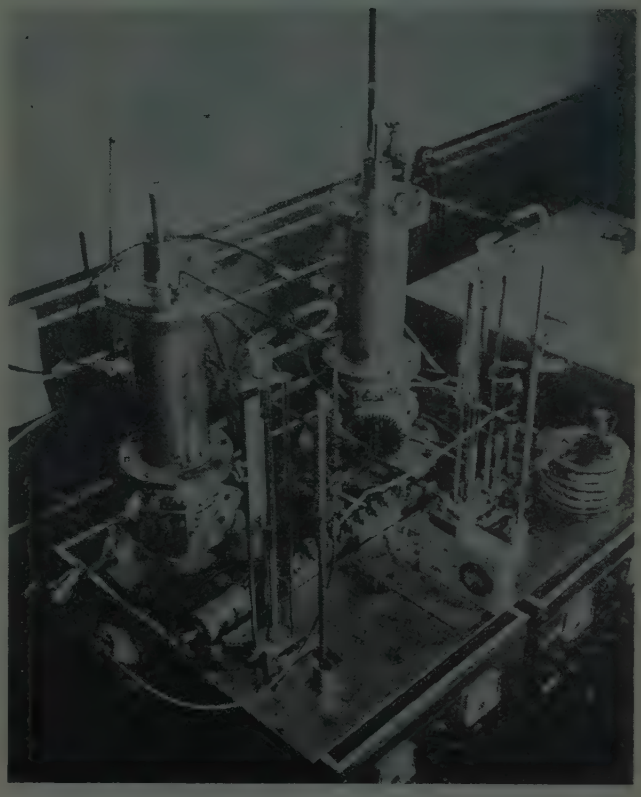

Fig. 1—Over-all picture of Stanford masers.

Fig. 2 shows the arrangements of these parts without the vacuum system. The ammonia is supplied from a large tank through a needle valve to the beam collimator which consists of a large number of long tubes through which the gas is allowed to diffuse. The beam entering the focuser from the collimator has reasonable directivity and is relatively dense.

The focuser consists of a number of parallel rods placed symmetrically about the beam axis and alternately biased to a high potential. This configuration produces a large inhomogeneous electric field in the region of the beam. The electric field may be thought of, in the classical sense, as inducing an average dipole moment in the ammonia molecule. The field, in turn, applies a force to the dipole moment which tends to focus the high-energy molecules toward the beam axis and defocus the low-energy molecules out through the rods.

* Original manuscript received by the IRE, October 6, 1958; revised manuscript received, March 24, 1959.

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Fig. 2—Beam collimator, cavity and focuser.

The focuser is sufficiently effective to permit, in the first approximation, only high-energy molecules to enter the cavity. Each high-energy molecule is capable of radiating a quantum of energy, $E=hf_{kn}$. The beam entering the cavity is thus a potential source of microwave energy. If the cavity is tuned to the transition frequency f_{kn}, and if the density of high-energy molecules is sufficiently great, the noise energy at f_{kn} is amplified until the induced emission of radiation from the molecules causes the system to break into oscillation. Molecules leaving the cavity and passing through the focusing rods are pumped away with a small diffusion pump and a liquid nitrogen cold trap.

To utilize the maser as a frequency standard, it is necessary to know how the frequency of oscillation varies as a function of the system parameters; *i.e.*,

1) the *source pressure*, P, or pressure of the ammonia gas on the back of the effuser tubes,
2) the *focusing voltage*, FV, or the potential between alternate rods of the focuser, and
3) the *cavity tuning*, ct, or the resonant frequency of the cavity.

With the equipment indicated by the block diagram in Fig. 3, it is convenient to measure the relative frequency and amplitude of a maser oscillator as a function of these operating parameters. Unfortunately, the source pressure and focusing voltage do not bear a simple relation to the theoretically important *beam current*, which is defined as the difference between the number of high and low-energy molecules in the energy state of interest entering a cavity per second. The molecule-to-molecule collisions, and the hyperfine structure of the emission line, make the relation between these operating parameters and the beam current difficult to compute.

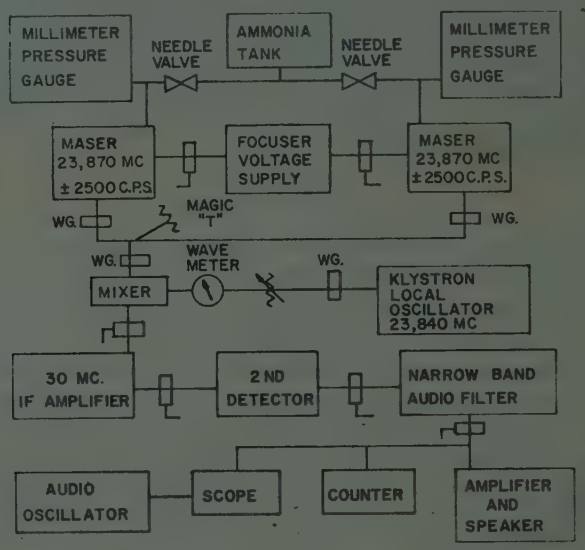

Fig. 3—Block diagram for measuring variations in frequency and amplitude.

Explanation of Maser Operation

Professor Townes and his associates [23], [43] worked out the theory of operation for ammonia beam maser under the simplified assumption of a uniform beam velocity. For this condition, they have predicted the magnitude of various sources of frequency pulling. Helmer and Lamb [25a] extended the theory to the case of a beam with a Maxwellian velocity distribution. Recent papers by Helmer [26] and Shimoda [44] have extended the theory to cover the divergence of the beam and the effects of the unresolved hyperfine structure.

Distribution of Energy in Ammonia Gas

In thermal equilibrium, the density of molecules in a given state is proportional to $e^{-E/kT}$, where E is the total energy of the state, k is Boltzmann's constant, and T is the absolute temperature. This internal energy is distributed among various modes of rotation and vibration. The Stanford masers were designed to operate on the frequency of the inversion transition of the $J=3$, $K=3$ rotational state, where J and K are quantum numbers which specify the total angular momentum and its projection on the axis of symmetry.

The $J=3$, $K=3$ state has the largest population of ammonia molecules at room temperature, containing

approximately 6 per cent of the molecules [25a]. The ratio between the densities of the molecules in the high and low-energy inversion levels for a specific rotational state is approximately $e^{-hf/kT}$. For the inversion transition at 23.87 kmc, $hf/kT=1/250$, so that the inversion levels are nearly equally populated. Thus, approximately 3 per cent of the molecules entering the beam collimator are in the high inversion state and are potentially useful for maser operation.

Operation of the Beam Collimator

The beam collimator and focusing system must supply at least 10^{13} high-state molecules per second to the cavity. The effectiveness of the focuser in separating the high and low-energy molecules decreases rapidly with the increasing radial velocity of the entering molecules. When the mean-free-path of the molecules is large compared to the dimensions of the individual tubes of the effuser, it is possible to calculate the distribution of molecules leaving a single tube. At a large distance from the effuser, the angular distribution of the molecules leaving the effuser is approximately the same as the angular distribution from a single tube.

The angular distribution of the molecules coming from a long tube for angles $\theta>\tan^{-1} a/l$ is given by $dN=(4/3\pi)(a/l)\cot\theta dN_0$ where a and l are respectively the radius and length of the long tube, and dN_0 is the cosine distribution of molecules entering the tube from a gas at equilibrium [2]. Most of the molecular flow is contained in an angle defined by $\theta=\tan^{-1} 2a/l$ [34].

In practice, the maser effuser operates in the transition region between viscous and free molecular flow. Thus the mean-free-path is less than the diameter of the tubes at the entrance and greater at the exit. The angular distribution of the molecules, therefore, is expected to be largely determined by the exit portion of the long tube which is operating in free molecular flow. The effective length of this exit portion of the tubes decreases with increasing source pressure and the resulting divergence of beam increases.

Operation of the Focuser

The forces separating the high and low-energy inversion states of the ammonia molecule may be derived from the expression for the total energy of the molecule in an electric field. For ammonia this energy is given by [48], [22]

$$W_{12}=W_0\pm\left[\left(\frac{hf_{kn}}{2}\right)^2+\left(\frac{|\mu|EMK}{J(J+1)}\right)^2\right]^{1/2} \quad (1)$$

where h is Planck's constant, f_{kn} is the frequency of oscillation characterizing the inversion transition of interest, W_0 is the rotational energy of the molecules, E is the electric field, $|\mu|$ is the effective dipole moment, and M, K, and J are quantum numbers. The radial force exerted by the focuser on the induced dipole moment of the ammonia molecules is given by the gradient of the energy; or

$$f_r=\mp\frac{2}{hf_{kn}}\left[\frac{|\mu|MK}{J(J+1)}\right]^2 E\frac{\partial E}{\partial r}=\frac{CM^2}{4}E\frac{\partial E}{\partial r}, \quad (2)$$

where for the $J=3$, $K=3$ inversion transition of the ammonia molecule, C is equal to 3×10^{-36} farad-m^2, and M is the quantum number which describes the projection of the angular momentum in the direction of the electric field.

In the particular case of the Stanford masers, the quadrupole electric field is described by $|E|=|(2V_0/a^2)r|$, where V_0 is the potential between the surface of adjacent rods, a is the separation of the edge of the rods from the axis, and r is the distance from the axis. The resulting trajectories for particles passing through this focuser are portions of a sine wave which may be written in the form

$$r=R_0\sin(\gamma t+\phi_1), \quad (3)$$

where R_0, γ, and ϕ are constants which are defined by the initial conditions of a molecule entering the focuser, the geometry, and the focusing voltage.

It is possible to make a useful estimate of the velocity distribution of the molecules leaving the focuser and the focuser efficiency, with the following simplifying assumptions:

1) The effuser may be treated as a point source with the angular distribution for the molecules leaving it as measured by Helmer in Fig. 4.
2) The molecules coming from the effuser in each element of a solid angle contain a Maxwell distribution of speeds. This means that the probability of a molecule having a given speed is independent of direction.
3) The effect of fringing fields may be neglected.
4) A focused molecule is one for which r never exceeds the radius to the edge of the focusing rods.

Under these assumptions, the velocity distribution for molecules leaving the focuser is shown in Fig. 5 [2].

The results shown in Fig. 5 have several important consequences with respect to the frequency pulling characteristics of a maser oscillator:

1) The most probable velocity of the molecules entering the cavity is considerably less than the most probable thermal velocity.
2) This velocity is a function of focusing voltage, the quantum number M, and the angular distribution of the molecules coming from the effuser.
3) By substituting in the constant for the Stanford quadrupole focuser, it can be shown that the total focusing efficiency can be expected to be approximately 0.2 per cent of the total number of entering molecules.
4) Integration of the area under the curves in Fig. 5 shows that the number of focused high-state molecules increases approximately as the square of the voltage.

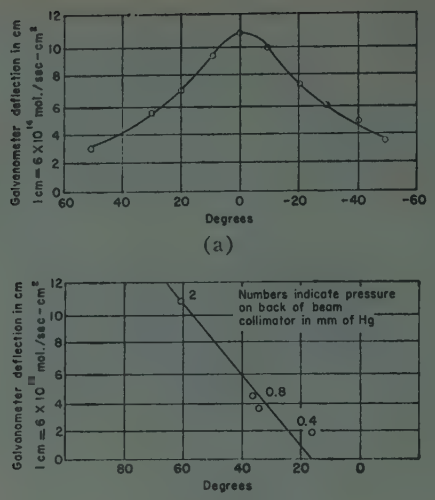

Fig. 4. (a) The measured angular distribution of molecules flowing out of the beam collimator. (b) The density at half peak intensity as function of the angular separation between half intensity points. (Varian Assoc. Rept. 25c)

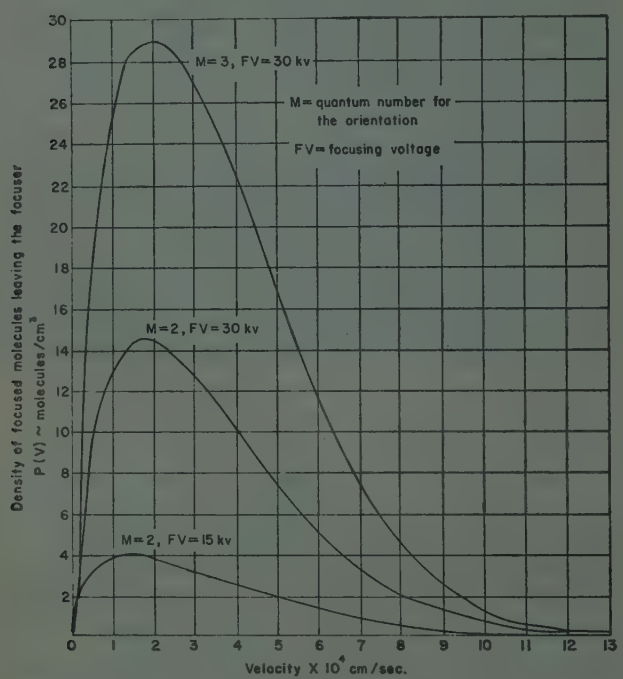

Fig. 5—The beam density of high state $J=3$, $K=3$ molecules leaving the focuser as a function of velocity.

A calculation of the number of low-state molecules which are defocused shows that the number of low-state molecules in the quantum states of interest entering the cavity equals about 15 per cent of the number of high-state molecules [2].

Molecular Collisions

In addition to the radiation induced by the electric field in the cavity, the high-state molecules may be caused to radiate by means of a dipole interaction between two passing molecules, and these collisions tend to return the system to thermal equilibrium. The molecules in the beam may collide with either the residual background gas or with other molecules in the beam traveling at a different velocity.

Since the operation of the maser is critically dependent upon the ability of the focuser to supply an excess of high-state molecules to the entrance of the cavity, the density in the region of the focuser must be low enough so that the mean-free-path of the molecules is large compared to the distance from the beam collimator to the entrance of the cavity. For the Stanford masers, this distance is about 30 cm. Therefore, the density of ammonia molecules must be less than about 1.6×10^{11} molecules/cm^3, corresponding to a pressure of about 2×10^{-5} mm of Hg. For greater pressures the effective length of the focuser appears to be shortened.

In both the cavity and the focuser, the effective density of the molecules is greater than in the general vacuum system. A portion of both the low and high-state molecules with large radial velocities is reflected from the walls of the focuser and the cavity. In the particular case of the Stanford masers, the molecules which are not focused make, on the average, about one additional trip across the beam before they escape. Thus, the density of the gas in the focusing region should be about 3/2 the density of the molecules in the beam.

Emission of Radiation in a Resonant Cavity

To a first approximation, all the molecules coming from the focuser are in high-energy inversion states. If these molecules are induced to make a transition between two adjacent quantum states, the power available is given by:

$$W = Nhf_{kn}P_n, \tag{4}$$

where N is the number of molecules in the high-energy inversion state of interest entering the cavity per second, h is Planck's constant, f_{kn} is the transition frequency, and P_n is the average transition probability.

The transition probability P_n contains terms due to both spontaneous and stimulated emission probabilities. The probability of spontaneous emission is very closely related to the noise properties of the maser amplifier which have been extensively treated in the literature [1], [21], [27], [29], [39], [41], [46], [49]. However, for the case which we are considering, this probability of spontaneous emission is negligible compared to the stimulated emission due to the electromagnetic field in the resonant cavity.

The induced transition probability depends upon the details of the electromagnetic fields and can be found from the solution of the time-dependent Schrödinger equation. For our purposes, however, it is more convenient to work with the related effective beam current which is defined by

$$J = n\frac{\partial P}{\partial t}, \tag{5}$$

where n is the density of the molecules per unit volume, t is the time, and P is the polarization vector. The polarization vector is related to the transition probability through the time-dependent coefficient for the eigenfunctions of the solutions to Schrödinger's equation. Helmer and Lamb [25a] have applied these results to the solution of Maxwell's equations in a beam-loaded cavity to obtain values for the frequency and amplitude of oscillation with a velocity distributed beam as shown below.

$$-\frac{1}{2}\frac{\Omega_c - \Omega_c^2}{\Omega_c} = \frac{\delta\sqrt{\pi}T_0 S(x)}{6Q_c}$$

$$\text{or } \delta \approx \frac{(\Omega_c - \omega_{kn})}{\Omega_c}\frac{6Q_c}{\sqrt{\pi}T_0 S(x)} \tag{6}$$

$$\frac{1}{Q_c} = \frac{nT_0}{\sqrt{\pi\epsilon\hbar}}|\mu|^2 G(x) \tag{7}$$

where

$\delta = \Omega - \omega_{kn}$,

$|\mu|$ is the matrix element,

T_0 = the most probable flight time through the cavity,

$S(x)$ = the function shown in Fig. 6,

n = net density of active molecules entering the cavity for the transition of interest,

$G(x)$ = function shown in Fig. 7,

$x = T_0\sqrt{\delta^2 + E\mu/\hbar^2}$,

$J = 1/G(x)$ = the beam current normalized to the starting flux.

Shimoda, Townes, and Wang [43] found the frequency and amplitude of oscillation for the case of a uniform beam velocity and a cavity operating in the TM_{010} mode to be given by

$$\delta = \left(\frac{\Omega_c - \Omega}{\Omega_c}\right)\frac{2Q_c}{T_0}\left(\frac{1 - \cos 2\theta}{1 - \dfrac{\sin 2\theta}{2\theta}}\right) \tag{8}$$

$$\frac{1}{Q_c} = \frac{4n\hbar}{E^2}\sin^2\theta \tag{9}$$

where

$$\theta = \frac{E|\mu|T_0}{2\hbar}.$$

The amplitude of oscillation as a function of the beam current predicted by the two theories is shown in Fig. 8. These curves are obtained when the cavity is tuned to f_{kn} or line center. The beam current needed to start oscillation is increased as the cavity is detuned from f_{kn}.

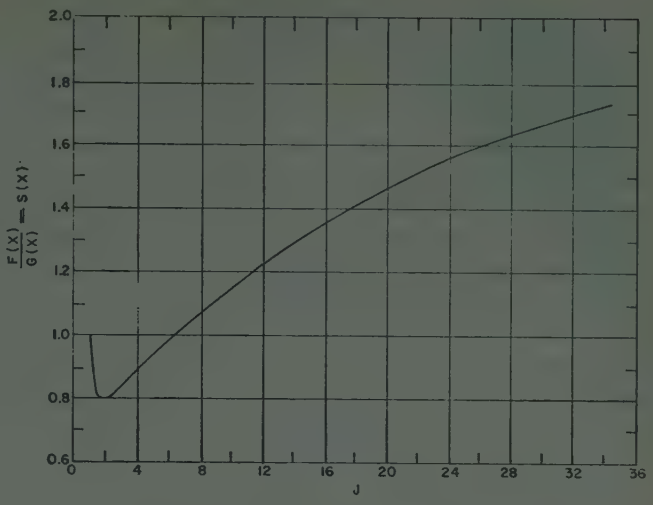

Fig. 6—Frequency stabilization factor $S(x)$ as a function of the normalized beam current J.

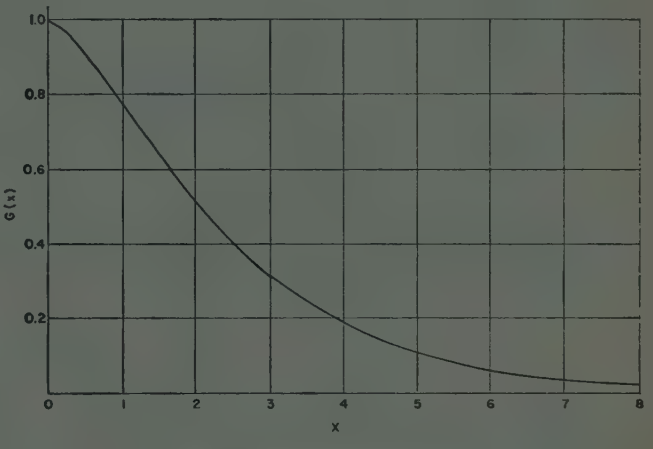

Fig. 7—The function $G(x)$ vs x.

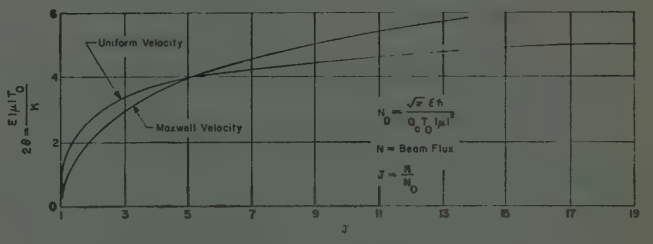

Fig. 8—The amplitude of oscillation as a function of beam current J.

The variation in frequency as a function of beam current is shown in Fig. 9 for the Maxwell velocity theory and in Fig. 10 for the uniform velocity theory. A comparison of these curves with the experimental results in Fig. 16 shows that this description is inadequate, and the unresolved hyperfine structure of the $J=3$, $K=3$ line must be considered.

The variation in intensity of the hyperfine components of the $J=3$, $K=3$ line with variation in beam current is treated in considerable detail by Shimoda

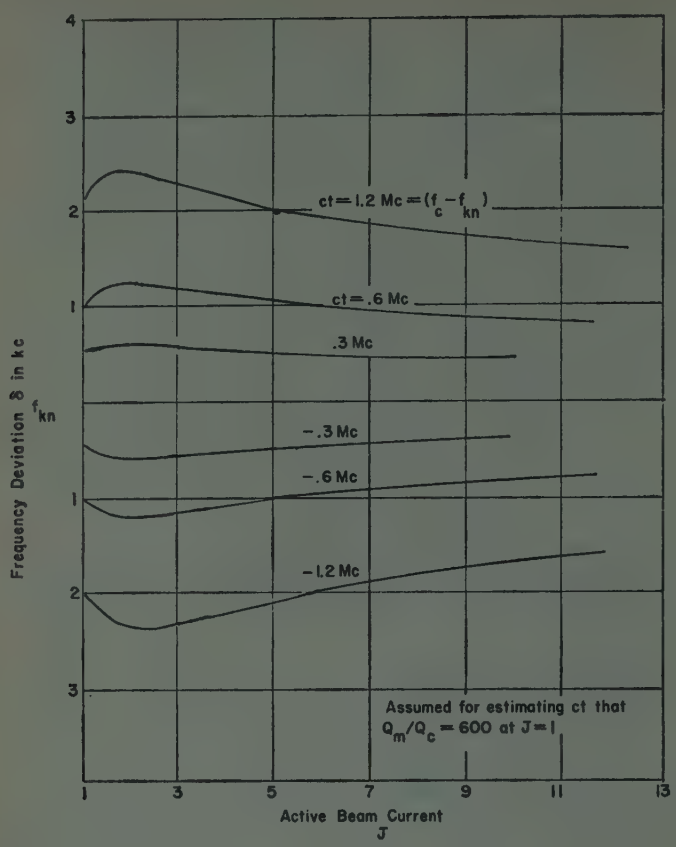

Fig. 9—Frequency of oscillation vs beam current as a function of ($f_c - f_{kn}$) for Maxwell velocity distributed beam.

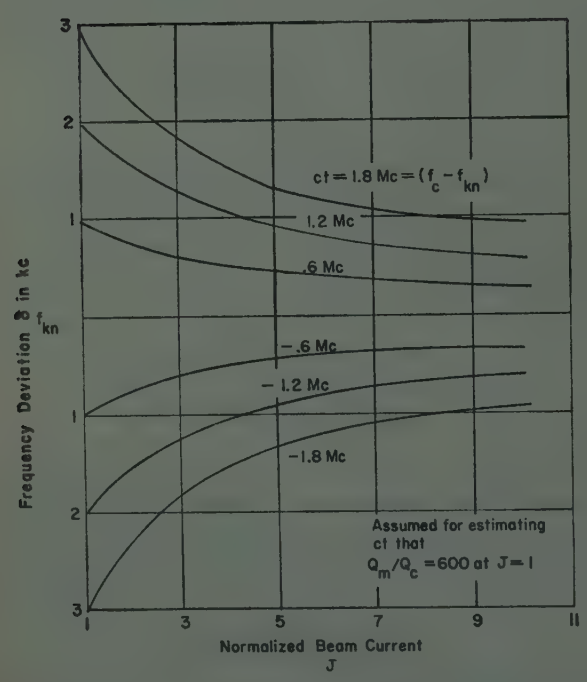

Fig. 10—Frequency of oscillation vs beam current as a function of ($f_c - f$) for a uniform velocity beam.

[44]. He shows that each of the three hyperfine components may be treated separately with equations of the form of (8) and (9). The resulting characteristics are obtained from the sum of these components with the appropriate weight factors, which account for the differences in the hyperfine state populations and the efficiency of the focuser. These calculations predict the asymmetric characteristic of the amplitude vs cavity tuning characteristics shown in Fig. 11, and a variation in the effective line center, as a function of focusing voltage, as shown in Fig. 12.

Other terms which are important in determining the frequency of oscillation of the maser cavity include unbalanced traveling waves in the cavity and molecular collisions. The shift due to unbalanced traveling waves may be as large as a few parts in 10^9 and is at least par-

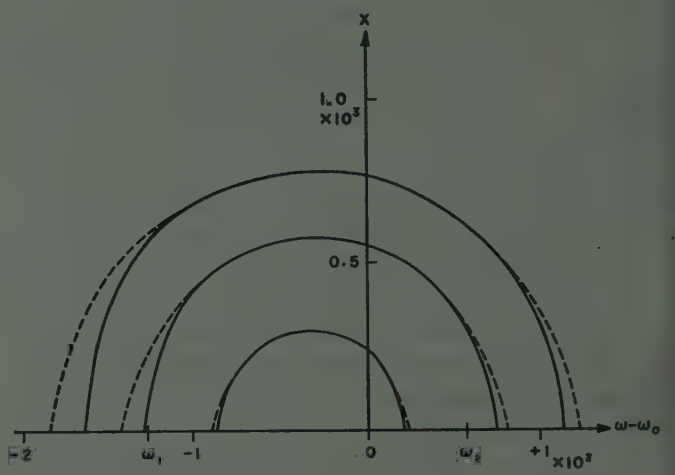

Fig. 11—Amplitude vs frequency characteristics. Dotted curves show plausible modifications for the hyperfine structure (Shimoda).

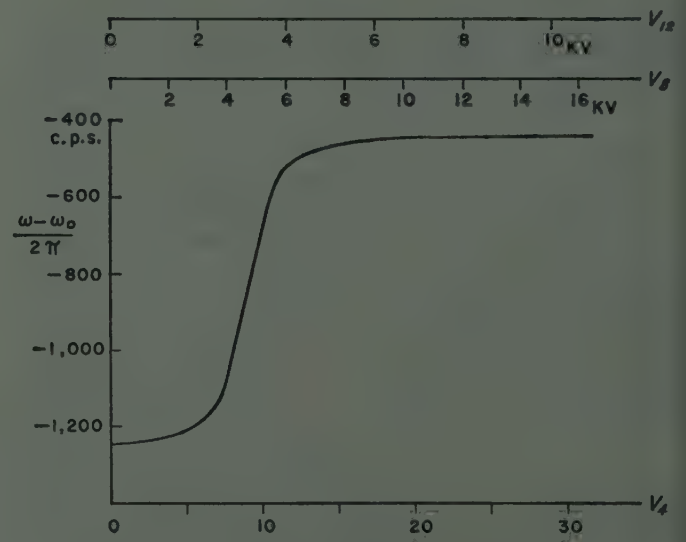

Fig. 12—Calculated frequency shift of the 3.3 line due to unresolved hyperfine structure. Changes of relative intensities by saturation effect are neglected. $V_4 V_8 V_{12}$ refer to the potentials on Shimoda's four-, eight- and twelve-pole focusers [44].

tially unavoidable. The physical location for the point of the maximum probability for the emission of radiation changes with the electric field strength and, thus, the beam current. The shift due to molecular collision may amount to as much as a few parts in 10^9. The molecules which make collisions either with the cavity wall or other molecules may be induced to radiate with a phase constant which is not coherent with the electromagnetic field in the cavity. Shifts as large as 2 parts in 10^9 have been measured at the Bureau of Standards by reversing the direction of the travel of the beam through the cavity [33]. The relative importance of these and other smaller sources of frequency shifts is treated by Shimoda, Townes, and Wang [43].

The density of molecules in the cavity resulting from the divergence of the beam may be calculated from the formula given by Dushman [18] for the ratio of the rate at which a gas enters and leaves a long tube. For the case of the 6-inch Stanford cavities, this ratio is about 0.17, and about 30 per cent of the molecules entering the cavity are sufficiently divergent to strike the wall. Thus, the density of molecules in the cavity is about twice that of the entering beam.

The effective range over which a maser oscillator may be tuned by varying the resonant frequency of the cavity is largely determined by the flight time of the ammonia molecules through the cavity and the resonant mode in which the cavity is operating. For the operation of the Stanford masers in the TM_{011} mode, the resulting tunable range of operation is about 3000 cycles.

If the cavity is operated in the TM_{012} mode or other modes with more than a half a sine wave, the variation of the field seen by the molecules resolves the ammonia line into two components [22], [25c]. This effect can be most easily visualized by considering the ammonia molecules to interact with first one and then the other of two traveling waves in the cavity, or when

$$f_{kn} = \frac{|v \pm v_p|}{\lambda_g}, \tag{10}$$

where v is the velocity of the molecule, v_p is the phase velocity of the electromagnetic waves, and g is the guide wavelength. At these two values of the phase velocity, or cavity tuning, the moving molecules are influenced by the electromagnetic energy in the cavity. The separation between these frequencies is given by

$$\Delta f = \frac{2v}{\lambda g} = \frac{n'v}{L} \tag{11}$$

where n' is the number of half wavelengths along the cavity, and L is the length of the cavity.

The frequency and amplitude response for operation in the TM_{012} are predicted for small signal operation by Helmer [25c] by equating the resistance in the reactance of the cavity to the equivalent resistance and reactance of the beam, as computed by the solution of the time-dependent Schrödinger equation. These results are plotted in Fig. 13. The bandwidth of the cavity is so much broader than the effective bandwidth of the molecule that the reactance of the cavity appears as a nearly straight line with the slope of the order of 0.001 of that of the beam reactance. When the intersection of the two reactances passes through f_{kn}, the mode in which the transition probability is largest changes, and there is a discontinuity in the frequency of oscillation with the change in cavity tuning. This discontinuity, or jump, in frequency provides a means for estimating the average velocity of the beam and, in addition, provides a possible means for establishing line center or the natural transition frequency of the molecule.

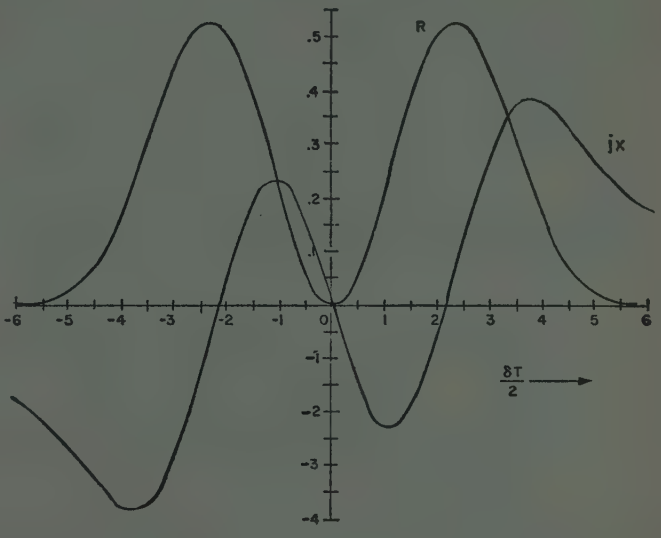

Fig. 13—The equivalent resistance R and reactance jX of the beam as a function of the product of the detuning δ and the average flight time T for operation in the TM_{012} mode (taken from Varian Assoc. Rept. 25c).

Results of Recent Experiments at Stanford

Fig. 14 shows the relative frequency of oscillation as a function of cavity tuning obtained during the recent Stanford tests for various focusing voltages at a nearly optimum source pressure. Both the uniform and Maxwellian velocity distribution theories predict a linear relation between the frequency of oscillation and the cavity tuning; and, the slope $\partial\Omega/\partial\Omega_c$ is determined by the length of the cavity, the velocity of the molecules, and the active beam current.

The relation of $\partial\Omega_c/\partial\Omega$ to focusing voltage, as obtained during the tests, is shown in Fig. 15. According to the Maxwellian velocity theory, $\partial\Omega_c/\partial\Omega$ should vary as $S(x)$. Note that the reversal of sign of the $S(x)$ at small currents is not observed.

Fig. 16 shows the relative frequency of oscillation as a function of focusing voltage at successive cavity tunings

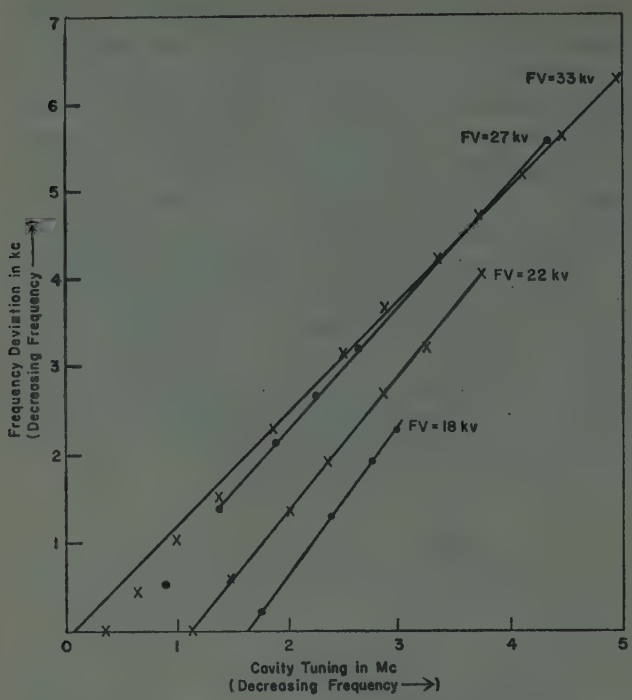

Fig. 14—The frequency of oscillation vs cavity tuning for various focusing voltages (FV) and source pressure $P=2.7$ mm of Hg.

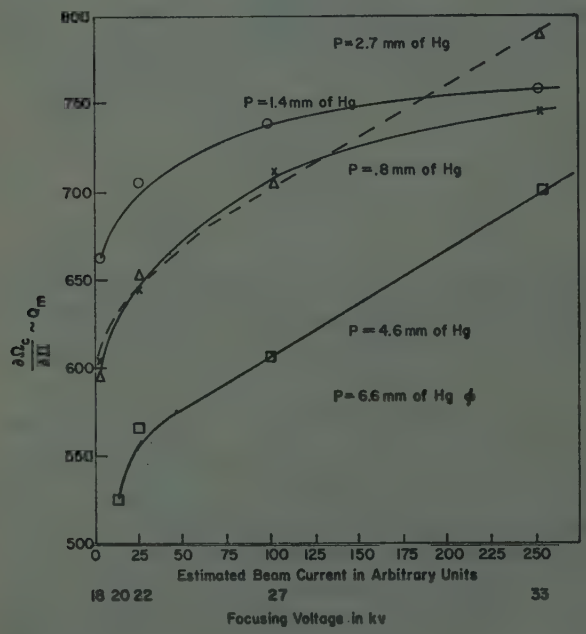

Fig. 15—The variation of the $\partial\Omega_c/\partial\Omega$ is plotted as a function of the beam current where it is assumed that the beam current increases as the square of the focusing voltage.

for nearly optimum source pressure. This graph may be compared with the predicted curve for the frequency as a function of the beam current in Fig. 9. When the cavity is widely detuned from the natural transition frequency of the molecules, the results agree quite well with the theory at large currents. However, the predicted

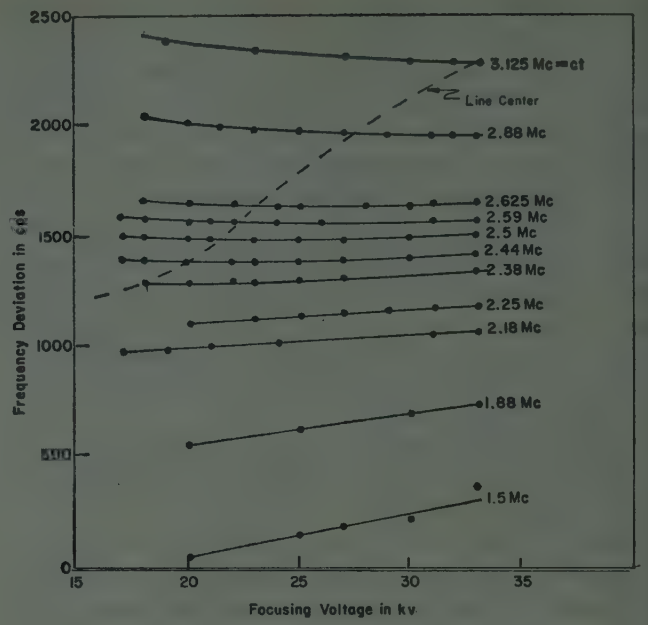

Fig. 16—The frequency of oscillation vs focusing voltage as a function of cavity tuning at source pressure $P=1.2$ mm of Hg.

reversal in direction of the frequency pulling again fails to appear at low currents.

A second and more important deviation from the simple theory is the movement of line center (or the position of cavity tuning for which the frequency is independent of focusing voltage) to higher frequencies with increasing focusing voltage. This effect is of the general form predicted by Shimoda [44] upon accounting for the hyperfine structure of the $J=3$, $K=3$ line.

Fig. 17 shows the frequency as a function of source pressure. At large pressures this frequency tends to move away from any position which might be called line center with increasing beam flux. This indicates that the beam current decreases with increasing beam flux for values greater than about 2×10^{15} molecules/cm^2. As the $\partial\Omega/\partial P=0$ for a reasonable range of CT at this beam flux density, it could be a useful operating point for a frequency standard.

The curves showing the amplitude of oscillation as a function of cavity tuning in Fig. 18 are sufficiently asymmetric to indicate that the ellipse predicted by (7a) must be modified, as suggested by Shimoda [43], to account for the hyperfine structure of the $J=3$, $K=3$ line. The curves for the maximum amplitude of oscillation as a function of focusing voltage (see Fig. 19) agree in general form with those predicted by (7) and (9). The measurements of the maximum amplitude as a function of source pressure in Fig. 20 definitely indicate a decrease in the active beam current for source pressure greater than 2 mm of mercury.

In order to obtain a better estimate of the change in beam current with changes in source pressure and focusing voltage, a gauge holder was built to permit

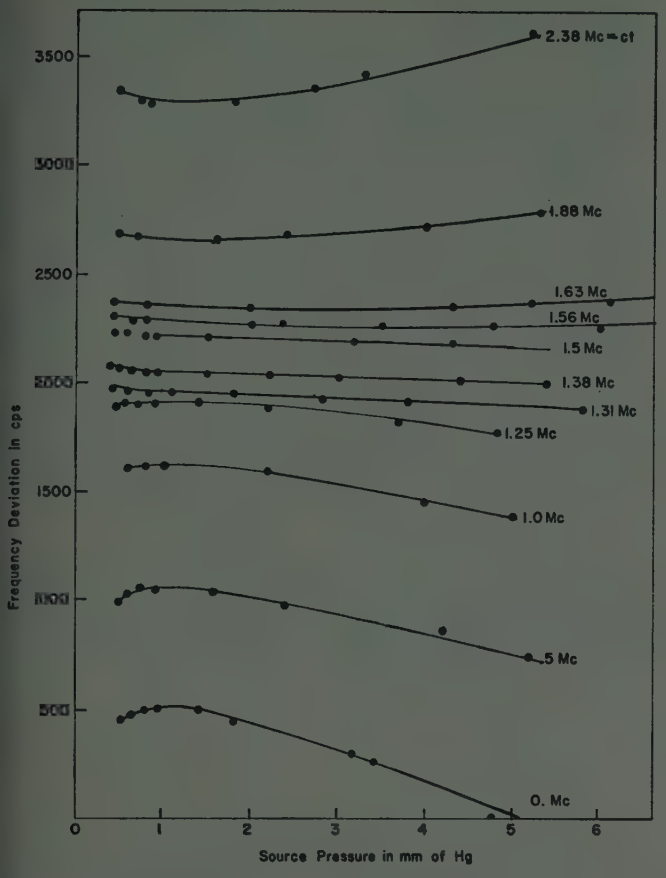

Fig. 17—Frequency of oscillation vs source pressure as a function of cavity tuning at a focusing voltage of 37 kv.

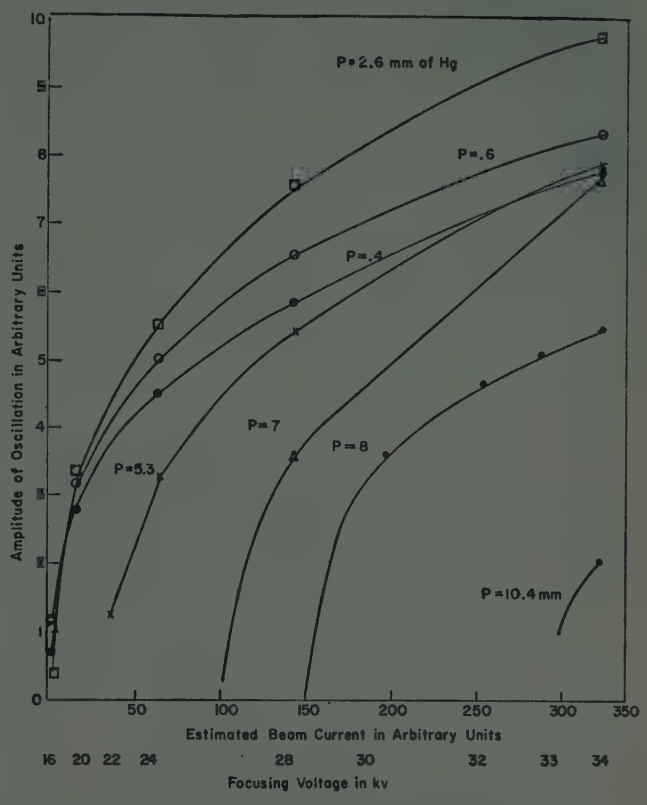

Fig. 19—Measured amplitude of oscillation vs estimated beam current as a function of source pressure.

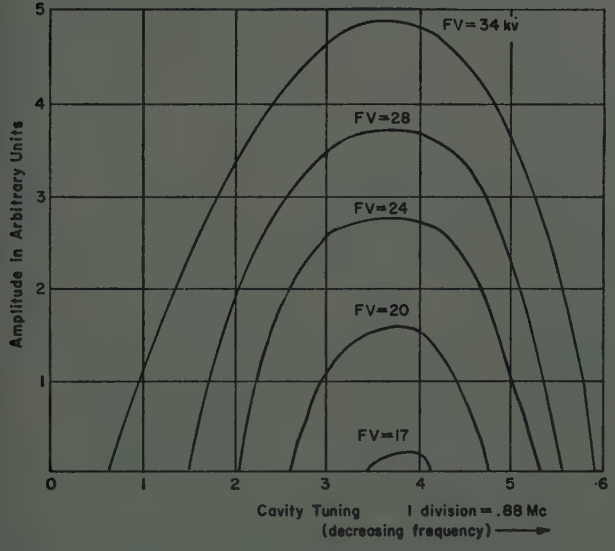

Fig. 18—Amplitude of oscillation vs cavity tuning as a function of focusing voltage at a source pressure $P=2.6$ mm of Hg.

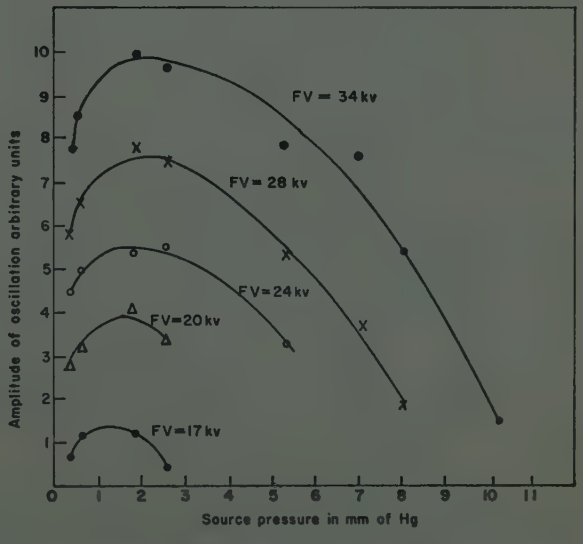

Fig. 20—Maximum amplitude of oscillation vs source pressure as a function of focusing voltage.

replacement of the maser cavity with either an ion or a Pirani gauge. These gauges provided the measurements in Figs. 21 through 24.

The plot of the beam flux vs source pressure in Fig. 21 shows that the beam flux is a monotonically increasing function of the source pressure over the maser operating range. This is in contrast to the measurements in Fig. 20, and must be accounted for in the difference between the dipole to dipole interaction cross section and the kinetic cross sections of the ammonia molecule. The ion gauge measurements in Fig. 22 show that a beam collimator pressure of 2 mm of mercury corresponds to a beam density in the cavity of about 1.6×10^{11} molecules/cm^2/sec and a mean-free-path of 26 cm. The maximum beam current indicated in Fig. 20 therefore occurs when the mean-free-path of the molecules in the cavity becomes approximately equal to the dimensions of the focuser.

The minimum beam flux at the cavity entrance for which the Stanford masers will oscillate is approximately 2×10^{14} molecules per second. About 6 per cent of these molecules (1.7×10^{13} per sec) should be in the high inversion level of the $J=3$, $K=3$ rotational state. This is in excess of the 5×10^{12} molecules per second which are necessary to start oscillation, as indicated by calculations from (7). The difference between these two numbers probably results from disregarding the divergence of the beam.

The application of the focusing voltage produces an increase in the beam flux at the cavity entrance, which varies approximately as the square of the focusing voltage and has a maximum of about 10 per cent of the initial flux. At low focusing voltages nearly equal numbers of molecules are expected to be focused and defocused. However, at high focusing voltages nearly all the low-state molecules which would enter the gauge have been defocused, and the density of molecules increases with the number of focused high-state molecules. The square law increase shown by the experimental data in Fig. 23 is in close agreement with the theory.

Fig. 24 shows that the beam flux decreases rapidly as the distance from the beam collimator increases. It should, therefore, be advantageous to use as short a focuser as will give adequate separation of states, and to mount the cavity as close to the focuser as possible. Measurements of the beam flux density at the entrance to the cavity showed the intensity to be practically constant across the cavity entrance, and that approximately 30 per cent of the molecules in the beam diverge sufficiently to collide with the cavity walls.

The graphs of the amplitude as a function of cavity tuning in Fig. 25 clearly demonstrate the Doppler splitting of the molecular resonance line into two components for operation in the TM_{012} mode. The frequency separation of the peaks varies from 5 to 8 kc. and the simple theory predicts a corresponding velocity of 3 to 4 times 10^4 cm/sec. These velocities indicate that the average velocity of the beam is considerably less than the average thermal velocity of 6 times 10^4 cm/sec but greater than the 2 times 10^4 cm/sec predicted by the preliminary calculations. The asymmetry of the $J=3$, $K=3$ line is also clearly demonstrated.

The discontinuity or jump in the frequency of oscillation predicted by the first-order theory for operation in the TM_{012} mode is shown in Fig. 26. The size of this

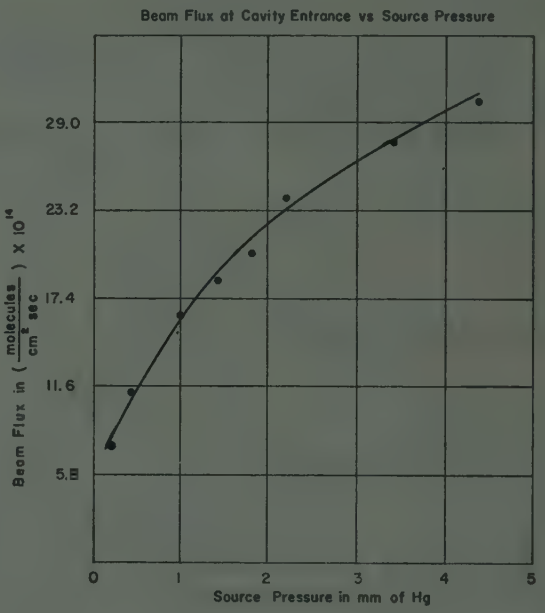

Fig. 21—The beam flux density at the cavity entrance as a function of the source pressure.

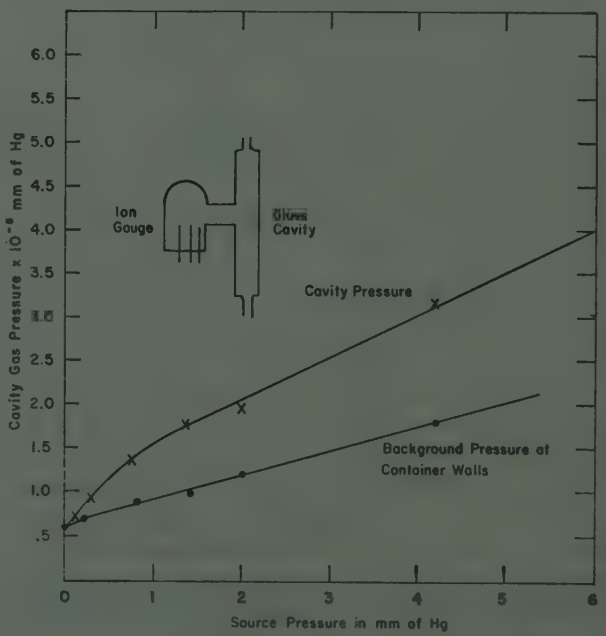

Fig. 22—The pressure of the gas in the cavity as a function of source pressure.

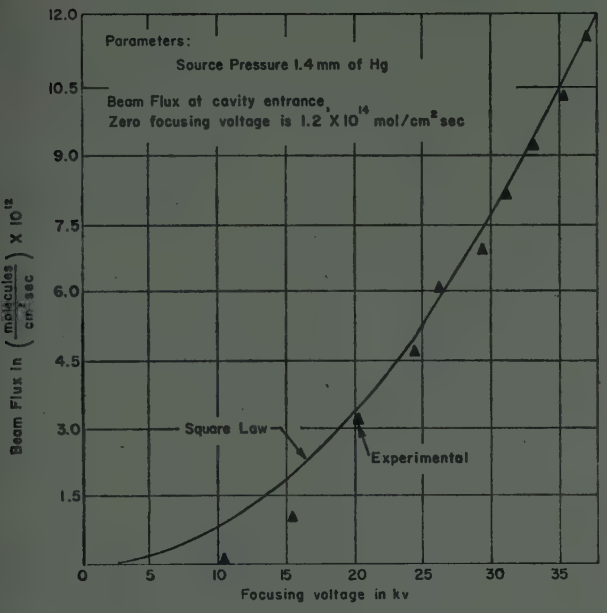
Parameters:
Source Pressure 1.4 mm of Hg
Beam Flux at cavity entrance,
Zero focusing voltage is 1.2 X 10^14 mol/cm^2 sec
Square Law
Experimental
Beam Flux in (molecules/cm^2 sec) X 10^12
Focusing voltage in kv

Fig. 23—Experimental measurement of the increase in beam flux at the cavity entrance as a function of focusing voltage.

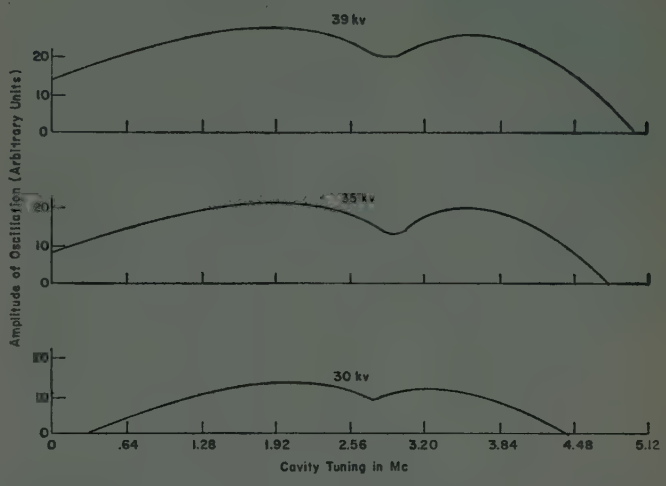

Fig. 25—The amplitude of oscillation vs cavity tuning as a function of focusing voltage for TM_{012} mode operation at source pressure $P=2$ mm.

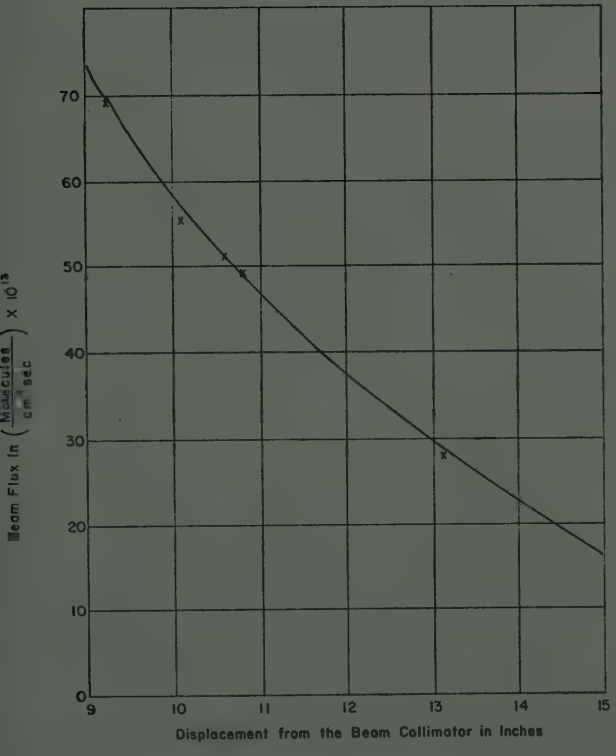

Fig. 24—Beam flux vs distance from the collimator along the axis at $P=1$ mm of Hg, $FV=25$ kv.

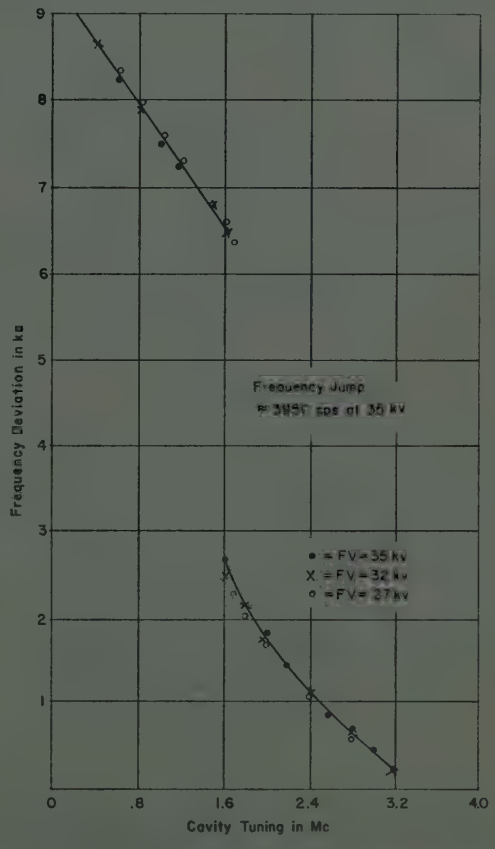

Fig. 26—Frequency of oscillation vs cavity tuning as a function of focusing voltage at a source pressure $P=1.8$ mm of Hg.

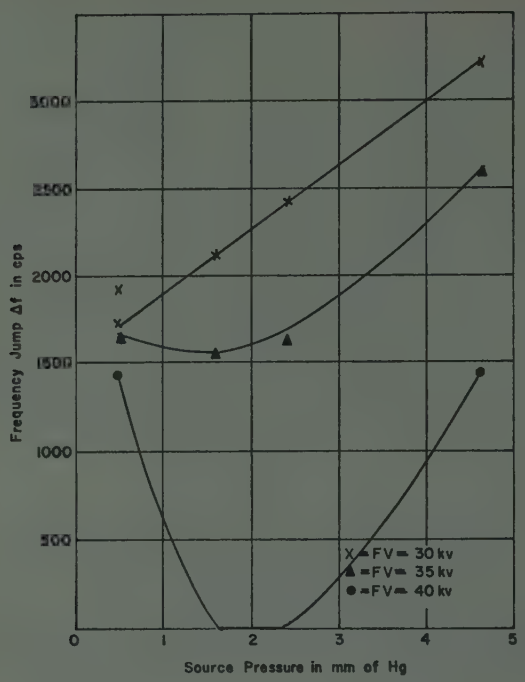

Fig. 27—The frequency discontinuity as a function of source pressure and focusing voltage for operation in the TM_{012} mode.

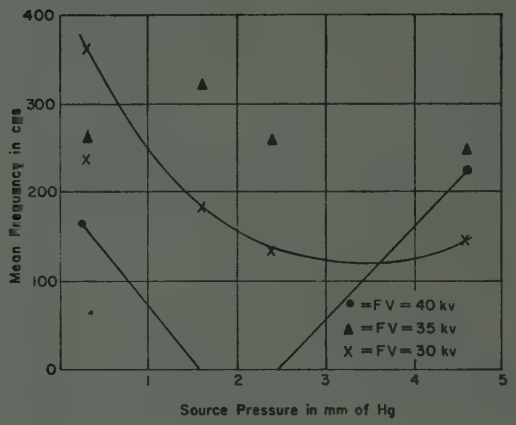

Fig. 28—The mean frequency of the TM_{012} mode jump vs source pressure as a function of focusing voltages, second maser.

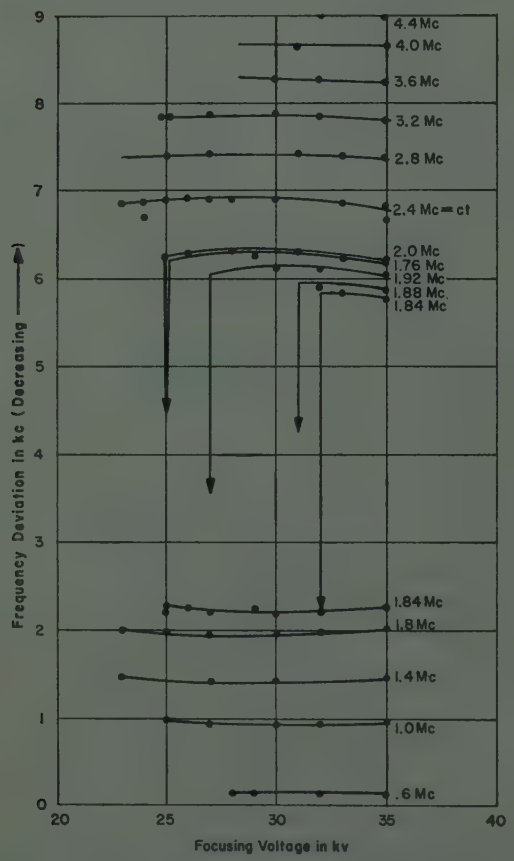

Fig. 29—Frequency of oscillation as a function of cavity tuning at source pressure of $P = 1.2$ mm of Hg for TM_{012} mode.

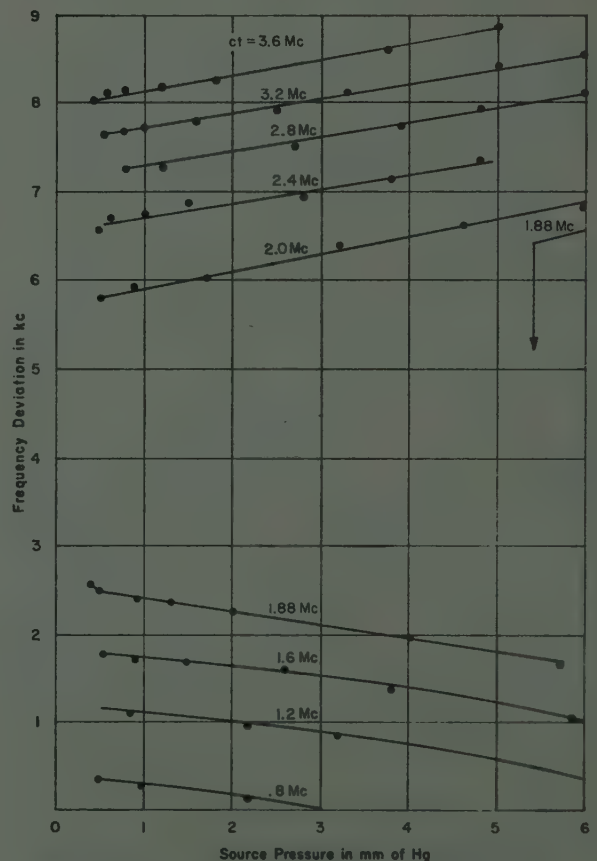

Fig. 30—Frequency vs source pressure as a function of cavity tuning at $FV = 37$ kv.

frequency jump varies with focusing voltage and source pressure, as shown in Fig. 27. Additionally, the mean frequency of this jump changes, as shown in Fig. 28.

The variation in the average velocity of the molecules, predicted from the small signal theory from the changes in the size of the velocity jump, is unreasonably large, and it is suspected that the variations in velocity are masked by more important changes in the beam current.

Another significant variation from the theory is the absence of a zero in the amplitude of oscillation at the natural transition frequency of the molecule. This indicates an asymmetry in the operation of the cavity which is probably caused by the divergence of the beam. It is also possible that some of the variation with focusing voltage of the location in the mean value of the frequency discontinuity is caused by a varying divergence of the beam current.

The mean frequency of the frequency jump has been proposed as a possible parameter for establishing the natural frequency of the molecule f_{kn} for use as a frequency standard independent of the particular system design. However, the results of Fig. 28 show that this mean frequency may be varied over a range of about 400 cps or 2 parts in 10^8 by changing the beam current.

Fig. 29 shows the frequency as a function of focusing voltage. The reversal in the sign of the $\partial\Omega/\partial FV$ with increasing focusing voltage, the dependence of the frequency of oscillation on the past history, and the divergence of the frequency with increasing beam pressure (Fig. 30) are features which have yet to be explained by large-signal theory.

Conclusion

In the development of an atomic frequency standard there are at least two important problems. The first of these is the development of an extremely stable oscillator which, once started, will maintain a given frequency to very high precision. The second problem is to find a unique reproducible frequency. These requirements are at least partly conflicting. In order to obtain an extremely stable source of oscillation, one wishes to make the oscillator as independent of as many operating parameters as possible. In the second case, it is desirable to make some property of one frequency as different as possible from all other frequencies.

Experimental results shown in Figs. 16 and 17 make it appear that it is possible to select a source pressure, cavity tuning, and focusing voltage such that variations in frequency due to changes in focusing voltage and source pressure are minimized. The existence of these minimums in the partial $\partial\Omega/\partial p$ and $\partial\Omega/\partial FV$ should be useful in determining the operating conditions for a frequency standard. Recent work at the National Bureau of Standards by R. Mockler and J. Barnes [23] on a carefully constructed temperature control circuit for the cavity has greatly reduced the principal source of frequency instability. With temperature stabilities of about 0.001°C, their initial results indicate that frequency stabilities better than 1 parts in 10^{12} should eventually be maintainable for indefinitely long periods. Bononami, *et al.* [12], have shown that a flat spot in a frequency vs cavity tuning curve may be obtained by critical-coupling two cavities. The use of these critically-coupled cavities reduces the stability requirements on the temperature control circuit for a given frequency stability by about an order of magnitude.

The foregoing experimental results also place some limits on the accuracy of several methods of establishing a unique frequency which is independent of the operating parameters. First, the location of line center by setting the $\partial\Omega/\partial FV=0$ may be varied over a range of about 1500 cycles with changes in operating parameters. A similar variation of approximately 1000 cycles is obtained for using the $\partial\Omega/\partial p=0$ as a means of establishing line center, even after the elimination of the region in which the changes in beam current change sign. Second, the mean frequency of the discontinuity for operation in the TM_{012} mode may be varied over a range of about 450 cycles with changes in operating parameters.

These variations in resetability are all orders of magnitude larger than the frequency drifts with time for a carefully constructed oscillator. It is suspected that the major causes of these variations in resetability are due to changes in the amplitude of the hyperfine components and the asymmetries in the radiation pattern due to the divergence of the beam.

A possible means for reducing this problem in resetability would appear to be to operate a maser on the $J=3$, $K=2$ line at 22.8 kmc [10]. This line has no hyperfine structure, and it is expected that operation on this line would reduce the variations in the foregoing methods for locating line center by an order of magnitude. Another possible means of eliminating the hyperfine structure is to use ammonia made from N^{15}.

Acknowledgment

The author is deeply indebted to Dr. J. C. Helmer for much of the equipment used in this work and for many helpful suggestions and discussions, and to Professor E. L. Ginzton for his direction and continuing interest in the work. Much of the Stanford work described in this paper was supported under U. S. Army Signal Corps contract No. DA-36-039 SC71178. Additionally, the bibliographies obtained from the frequency control branch of the Signal Corps have been extensively used in compiling the list of references.

References

[1] L. E. Alsop, C. H. Townes *et al.*, "Measurement of noise in a maser amplifier," *Phys. Rev.*, vol. 107, pp. 1450–1451; September 1, 1957. Effective noise temperature about 75K and about 6K above theoretical prediction.

[2] F. S. Barnes, "Experimental Study of an Ammonia Beam Maser," Microwave Lab., Stanford University, Stanford, Calif., Topical Rept. No. 486; February, 1958.

[3] N. G. Basov and V. M. Fain, "Molecular generator," (*USSR*), M. D. Friedman, Inc., Technical Translations, Newtonville, Mass.; January, 1957. NH_3 beam oscillator; the first results of the generator operation are cited.

[4] N. G. Basov and A. M. Prokhorov, "In Russia", *Soviet Phys. JETP*, vol. 27, p. 431; 1954.
[5] Y. Beers, "Theory of the cavity microwave spectrometer and molecular frequency standard," *Rev. Sci. Instr.*, vol. 30, pp. 9–16; January, 1959. Claims possibility 4×10^{12} stability NH_3 absorption.
[6] J. Blaser, and J. Bonanomi, "Comparison of an ammonia maser with a cesium atomic frequency standard," *Nature*, No. 4639, p. 859; September, 1958.
[7] J. Blaser, and J. De Prins, "Comparison of astronomical time measurements with atomic frequency standards," *Nature*, No. 4639, pp. 859–860; September, 1958.
[8] J. Bonanomi *et al.*, "Masers oscillating with cavity modes depending on cavity length," *Helv. Phys. Acta*, vol. 31, pp. 282–285; 1958. (In French.)
[9] J. Bonanomi *et al.*, "Comparison between determinations of astronomical time and atomic time," *Helv. Phys. Acta*, vol. 37, pp. 271–281; 1958. (In French.)
[10] J. Bonanomi *et al.*, "Maser oscillating on the ammonia line, $J=3$, $K=2$," *Helv. Phys. Acta*, vol. 31, p. 286; 1958. (In French.)
[11] J. Bonanomi *et al.*, "Stability of NH, frequency standards," *Helv. Phys. Acta*, vol. 30, pp. 288–290; August, 1957. (In French.) Review of Swiss work; reproducibility for a single maser 2×10^{-10}; frequency shift due to cavity length (5×10^{-10} per cm), focuser voltage (3×10^{-10} per kv) and beam density; agreement between identical masers, 10^{-9}; long-time stability 2×10^{-10}.
[12] J. Bonanomi *et al.*, "Twin cavity for NH_3 masers," *Rev. Sci. Instr.*, vol. 28, pp. 879–887; November, 1957.
[13] J. Bonanomi and J. Herrmann, "Determination of the inversion frequency of ammonia," *Helv. Phys. Acta*, vol. 29, p. 451; 1956. (In French.)
[14] J. Bonanomi, J. De Prins, J. Herrmann, and P. Kartschoff, "Improvement of an NH_3 maser," *Helv. Phys. Acta*, vol. 30, p. 492; 1957.
[15] F. P. Callahan, Jr., "Maser Theory," Internal Report, Philco Corp., Philadelphia, Pa.; May, 1957.
[16] J. P. Cedarholm *et al.*, "New experimental test of specific relativity," *Phys. Rev. Letters*, vol. 1, pp. 342–343; November 1, 1958. Masers used to test dependence of light velocity on velocity of reference frame; higher precision than that of Michelson experiment; maximum ether drift less than 1 1/1000 of earth's orbital velocity.
[17] W. M. Culver, "The maser," *Science*, vol. 126, pp. 810–814; October 25, 1957.
[18] S. Dushman, "Scientific Foundations of Vacuum Techniques," J. Wiley and Sons, Inc., New York, N. Y.; 1949.
[19] V. M. Fain, "On the equations of the oscillations of the molecular generator," *Soviet Phys. JETP*, vol. 33(6), 4, pp. 726–728; April, 1958. Equations are derived that describe stationary and non-stationary operating conditions of the molecular generator.
[20] R. P. Feymann, F. L. Vernon, and R. W. Hellwarth, "Geometrical representation of the Schrödinger equation for solving maser problems," *Jl Appl. Phys.*, vol. 28, pp. 49–52; January, 1957.
[21] J. P. Gordon *et al.*, "Noise in maser amplifiers—theory and experiment," PROC. IRE, vol. 46, pp. 1588–1595; September, 1958. Noise temperature 80°K (experimental), beam temperature 20°K (theoretical).
[22] J. P. Gordon, "Hyperfine structure in the inversion spectrum $N^{14}H_3$ by a new high-resolution microwave spectrometer," *Phys. Rev.*, vol. 99, p. 1254; 1955.
[23] J. P. Gordon, H. J. Zeiger, and C. H. Townes," The maser—new type of microwave amplifier, frequency standard, and spectrometer," *Phys. Rev.*, vol. 99, pp. 1264; 1955.
[24] J. P. Gordon, H. J. Zeiger, and C. H. Townes, "Molecular microwave oscillator and new hyperfine structure in the microwave spectrum of NH_3," *Phys. Rev.*, vol. 95, pp. 282–284; July, 1954.
[25] J. C. Helmer,
a) "Microwave Lab. Rept. No. 327," Stanford, California, September, 1956.
b) "Microwave Lab. Rept. No. 311," Stanford, Calif., 1956.
c) "Research on Molecular and Atomic Resonance Devices," Varian Quarterly Repts. Nos. 1–7, 1957–1959.
d) "Maser oscillators," *J. Appl. Phys.*, vol. 28, pp. 212–215; February, 1957.
[26] J. C. Helmer, "Small signal analysis of molecular beam masers," *J. Appl. Phys.*, vol. 30, pp. 118–120; January, 1959.
[27] J. C. Helmer, and M. Muller, "Calculation and measurement of the noise figure of a maser amplifier," IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 210–214; April, 1958.
[28] W. H. Higa, "Observations of nonlinear maser phenomena," *Rev. Sci. Instr.*, vol. 28, pp. 726–727; September, 1957. Two TE_{011} cavities in cascade.
[29] R. T. Jaynes, "Some Aspects of Maser Theory," Microwave Lab., Stanford University, Stanford, Calif., Microwave Lab. Rept. No. 502; May, 1958. Treats maser by quantum electrodynamics and semi-classically; latter method superior for many molecules case; also Microwave Lab. Rept. No. 547, August, 1958.
[30] V. M. Kontorovich and A. M. Prokhorov, "Nonlinear effects of the interaction of resonance fields in molecular generators and ampere vane," *Soviet Phys. JETP*, vol. 33(6), pp. 1100–1102; June, 1958.
[31] R. V. Khorhlov, "Lock-in of a molecular generator by a small external EMF," *Electronics Express*, vol. 1, pp. 9–10; September, 1958. (Excerpted from *Radiotekh. Elektron.*, vol. 3, pp. 279–282; February, 1958.) A theoretical treatment of the lock-in phenomenon.
[32] Y. L. Klimontovich *et al.*, "Contribution to the theory of the molecular generator," *Zhur. Eksptl. i Teoret, Fiz.*, vol. 32, pp. 1150–1155; 1957. (In Russian.) Detailed discussion of monovelocity beam maser.
[33] R. C. Mockler and J. Barnes, Natl. Bur. Standards, Boulder, Colo., private communication, August, 1959.
[34] M. Muller, "Research on Molecular and Atomic Resonance Devices," Varian Quarterly Rept. No. 1; September, 1957.
[35] M. Peter *et al.*, "Theoretical and experimental study of molecular beam microwave spectroscopy," Massachusetts Institute of Technology, Cambridge, Mass., R.L.E., M.I.T. Tech. Rept. No. 1; August 26, 1957.
[36] M. Peter *et al.*, "Efficiency of frequency, measurements with an atomic clock," PROC. IRE, vol. 47, pp. 92–93; January, 1959.
[37] A. M. Prokhorov, "A submillimeter wavelength molecular amplifier and oscillator," *Electronics Express*, vol. 1, p. 5; October, 1958.
[38] A. M. Prokhorov and P. N. Lebeder, "The effect of the quality of resonator on the frequency of molecular generator," *USSR Radio Engrg. and Elec.*, vol. 2, pp. 208–209; 1957. (English translation.) Must keep Q stabilized.
[39] I. R. Senitzky, "Induced and spontaneous emission in a coherent field," *Phys. Rev.*, vol. 3, pp. 3–12; July 1, 1958.
[40] L. I. Schiff, "Quantum Mechanics," McGraw-Hill Book Co., Inc., New York, N. Y.; 1949.
[41] A. E. Siegman, "Gain-bandwidth and Noise in Maser Amplifiers," Stanford Electronics Labs., Stanford, Calif.
[42] N. Sher, "A two-cavity unilateral maser," 1958 IRE NATIONAL CONVENTION RECORD, pt. I, pp. 27–36.
[43] M. Shimoda, T. C. Wang, and C. H. Townes, "Further aspects of the theory of the maser," *Phys. Rev.*, vol. 102, pp. 1308–1321; June, 1958.
[44] K. Shimoda, "Characteristics of the beam type maser I," *J. Phys. Soc. Japan*, vol. 12, pp. 1006–1016; September, 1957. Also, "Characteristics of the beam type maser II," *J. Phys. Soc. Japan*, vol. 13, pp. 939–947; August, 1958.
[45] M. L. Stitch, "Maser amplifier characteristics for transmission and reflection cavities," *J. Appl. Phys.*, vol. 29, pp. 782–789; May, 1958.
[46] M. W. P. Strandberg, "Computation of noise figure for quantum-mechanical amplifiers," *Phys. Rev.*, vol. 107, pp. 1483–1485; September, 1957. Noise figure expression in terms of physical quantities: *e.g.*, gain, Q, and salt molecular weight and volume.
[47] C. H. Townes, "Comments on frequency-pulling of maser oscillators," *J. Appl. Phys.*, vol. 28, pp. 920–921; August, 1957. Shows that cavity-pulling vs beam density predicted by theory using Maxwellian distribution does not describe observed data because the very slow molecules are not effective.
[48] C. H. Townes and A. L. Schawlow, "Microwave Spectroscopy," McGraw-Hill Book Co., Inc., New York, N. Y.; 1955.
[49] V. S. Troitskii, "Theory of the maser and maser fluctuations," *Soviet Phys. JETP*, vol. 34, (7), no. 2, pp. 271–273; August, 1958. Natural line width due to thermal noise is 10^{-4} cps for an NH_3 maser at room temperature.
[50] F. O. Vonbun, "Proposed method for tuning a maser cavity," *Rev. Sci. Instr.*, vol. 29, no. 9, p. 792; 1958. (See also errata in the January or February 1959 issue.)
[51] F. O. Vonbun, "Analysis of a multipole state separator and focuser for polarizable molecules," *J. Appl. Phys.*, vol. 29, No. 4, pp. 632–636; April, 1958.

Coaxial Resonators with Helical Inner Conductor*

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Summary—**The use of coaxial or reentrant resonators is practical at frequencies down through the high-frequency band and even lower. By introducing a helical inner conductor, a Q of several thousand can be achieved in relatively small volume. Design equations are simple and are the basis for an alignment chart. The unloaded Q is equal to 50 times shield diameter in inches times square root of resonance frequency in megacycles. Shield length is about 30 per cent greater than its diameter. Experimental results confirm the accuracy of the predicted Q. The method is also applicable to miniaturized UHF resonators, and to the design of high-Q radio-frequency inductors and LC resonators. Additional formulas and a chart relate frequency, Q, volume, voltage gradient and power rating.**

List of Symbols

b = axial length of coil, inches.
B = inside length of shield, inches.
C = capacitance, micromicrofarads per axial inch.
D = inside diameter of shield, inches.
d = mean diameter of turns, inches.
d_0 = diameter of conductor, inches.
f_0 = resonance frequency, megacycles.
I_{sc} = current at connection of coil to shield.
k = dissipation factor at surface of shield, watts per square inch.
L = inductance, microhenries per axial inch.
N = total number of turns of winding.
n = turns per inch.
P_c = power converted into heat in the resonator, watts.
P_m = maximum power available from a generator into a load, watts.
P_s = power rating of zero- or infinite-impedance generator, watts.
Q_d = doubly-loaded Q.
Q_s = singly-loaded Q.
Q_u = unloaded Q.
R_c = resistance due to coil conductor, ohms per axial inch.
R_s = resistance appearing in a coil due to the losses in the shield, ohms per axial inch.
V_{oc} = voltage at open-circuited end of coil.
(vol) = inside volume of shield, cubic inches.
Z_0 = characteristic impedance, ohms.
α = attenuation constant, nepers per unit length.
β = phase constant, radians per unit length.
δ = skin depth, inch.
$\tau = 1/n$ = pitch of winding, inches.
ϕ = proximity factor.

* Original manuscript received by the IRE, April 24, 1959; revised manuscript received, July 15, 1959. This paper was presented, in part, at the 1958 IRE National Convention, New York, N. Y.
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Introduction

RESONATORS of practical size with Q in excess of 1000 can be built for the hf and VHF ranges. They resemble the familiar coaxial-line quarter-wave resonator except that the inner conductor is wound in a helix. The technique can be extended even through the UHF range and beyond, where subminiature helical resonators can be built in smaller sizes than conventional ones when Q values between several hundred and 1000 suffice.

As an example of the saving of space and the much better shape factor, a helical resonator for 10 mc with unloaded $Q = 1000$ is about six inches in diameter by eight inches in length. In contrast, a TEM-mode coaxial-line resonator would be 25 feet in length by three inches in diameter. As an alternative solution, it might be possible to build a lumped (electrically short) inductor and capacitor tuned circuit with $Q = 1000$. However, it would tax one's ingenuity to fabricate it in a six- by eight-inch cylindrical shield.

Again, consider a subminiature resonator with $Q = 200$ for operation at 2000 mc. The helical type would be about one-tenth inch in diameter by one-eighth inch in length. A TEM-mode unit would be 1.5 inches in length by 0.05 inch in diameter.

Fig. 1 shows a series of resonator coils and their shield. The caption gives the resonance frequency and measured unloaded Q of each coil when mounted in the shield.

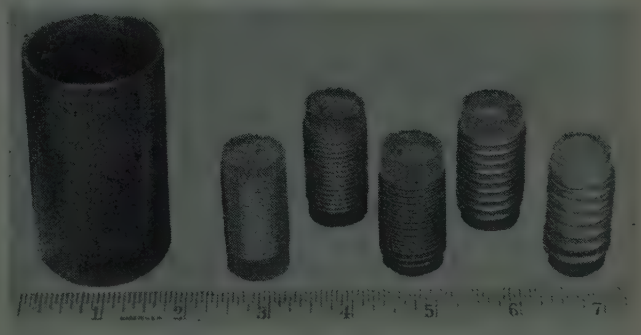

Fig. 1—Group of helical resonators. Shield inside diameter = 1.63 inches. Coils, from left to right: $f_0 = 55$ mc, $Q_u = 600$; $f_0 = 78$ mc, $Q_u = 720$; $f_0 = 101$ mc, $Q_u = 840$; $f_0 = 145$ mc, $Q_u = 880$; $f_0 = 215$ mc, $Q_u = 1000$.

The helical resonator (see Fig. 2) consists of a coil within a shield, one end of the coil being solidly connected to the shield. The other end is open-circuited, except possibly for a trimming capacitor. The resonator thus resembles an ordinary radio-frequency tuned circuit with the omission of the tuning capacitor. How-

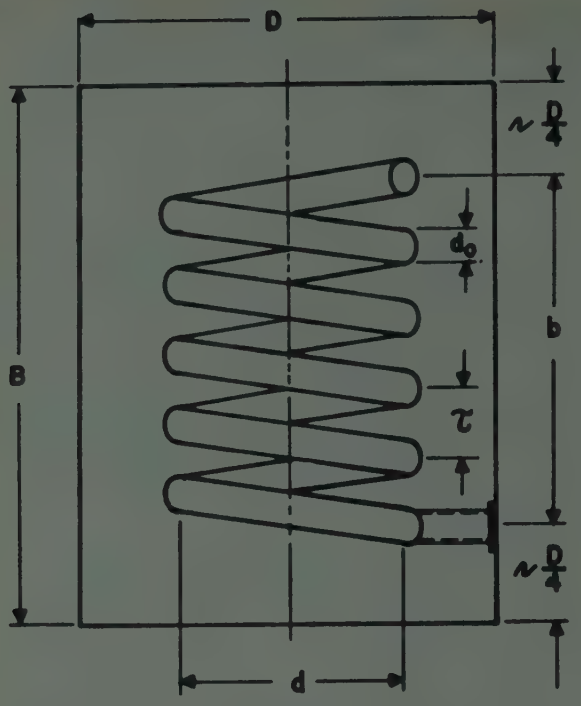

Fig. 2—Outline sketch of resonator.

ever, instead of being a lumped-constant device, its operation can be described in terms of its distributed inductance, capacitance, and resistance. The clearance at the top between the end of the helix and the shield is required to prevent voltage flashover, and the clearance at the bottom allows for passage of the magnetic field, thus reducing losses in the conductors. Resonance frequency and Q are about the same when the top and/or bottom are open as when they are closed. Probe, loop or aperture coupling can be used for the input and output circuits.

An idea of the size of the helical resonator for typical unloaded Q and resonance frequency can be gained from Fig. 3, which is plotted from (1), (5) and (7). The optimum range lies between the upper and lower dashed lines. At higher Q_u and f_0 a conventional coaxial resonator is frequently more desirable than the helical type. At lower Q_u and f_0 than the indicated range, a lumped LC circuit is often to be preferred.

A shielded inductor below its quarter-wave resonance frequency also has Q predicted by (1). Then a lumped LC resonant circuit has like Q, provided losses in the capacitor and connecting leads are reduced to a negligible value.

A similar problem has been developed by a somewhat different method than that used herein.[1] A report[2] of

[1] W. Sichak, "Coaxial line with helical inner conductor," PROC. IRE, vol. 42, pp. 1315–1319; August, 1954.

[2] R. G. Medhurst, "HF resistance and self capacitance of single-layer solenoids," *Wireless Engineer*, vol. 24, pp. 35–43, 80–92, 185, 281; February, March, June and September, 1947.

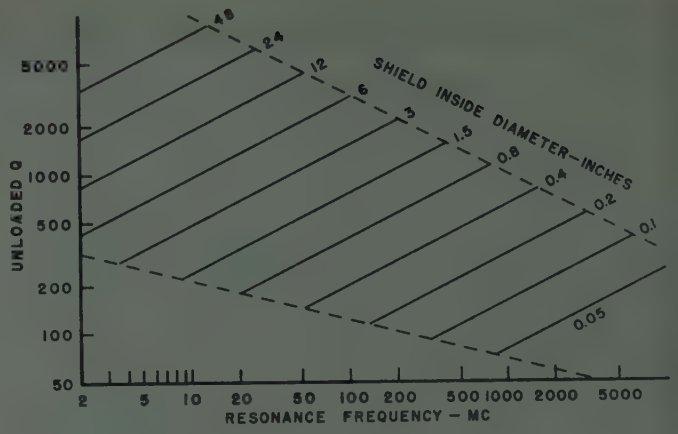

Fig. 3—Helical resonator unloaded Q.

extensive experimental work on the resistance and Q of unshielded single-layer solenoids includes tables and charts. This leads to a simple formula for the Q of an inductor similar to that given here for a resonator. A convenient compilation[3] of formulas for resonant lines in general has been made.

Design Chart

The alignment chart of Fig. 4 gives practical design and performance information. Due to the wide range of the parameters covered by the chart, and the latitude of possibilities in actual design and contruction of resonators, it is easily possible in specific cases to have variations of ± 10 per cent. The chart is drawn for the approximate optimum range of the parameters d/D, b/d and d_0/τ.

The equations and conditions for the scales of the chart are developed in later sections hereof. Summarizing:

Unloaded Q of a resonator consisting of a single-layer coil of copper conductor on a low-loss form, and enclosed in a copper shield:

$$Q_u = 50Df_0^{1/2}$$
$$0.45 < d/D < 0.6$$
$$b/d > 1.0$$
$$0.4 < d_0/\tau < 0.6 \text{ at } b/d = 1.5$$
$$0.5 < d_0/\tau < 0.7 \text{ at } b/d = 4.0$$
$$d_0 > 5\delta \text{ where } \delta = \text{skin depth.} \qquad (1)$$

Total number of turns:

$$N = 1900/(f_0D) \text{ turns}$$
$$d/D = 0.55$$
$$b/d > 1.0. \qquad (2)$$

[3] "Reference Data for Radio Engineers," fourth ed., ITT Corp., New York, N. Y., pp. 574–582, 600–603; 1956.

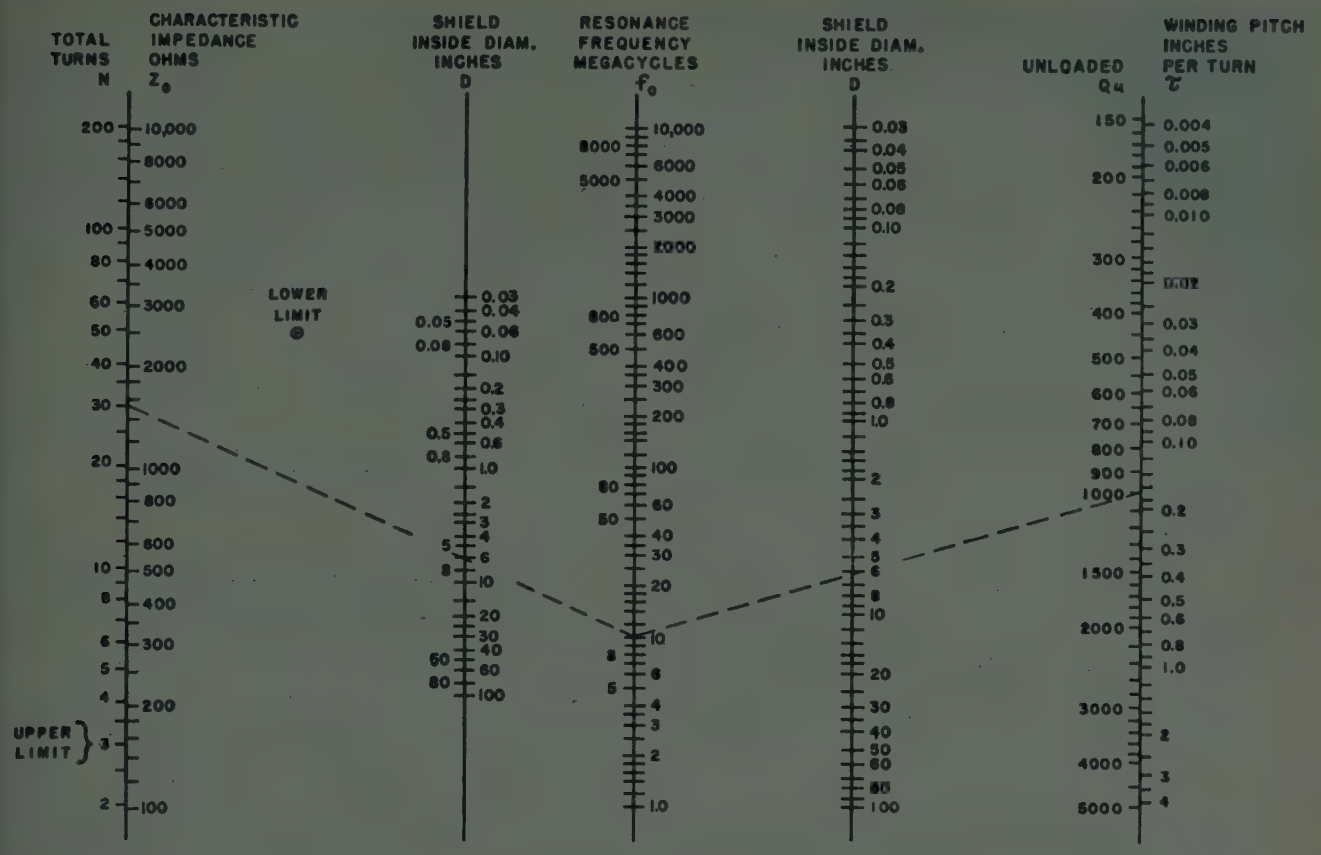

Fig. 4—Design chart for quarter-wave helical resonators.

Pitch of winding and characteristic impedance:

$$\tau = 1/n = (f_0 D^2)/2300 \text{ inches per turn} \quad (3)$$

$$Z_0 = 98{,}000/(f_0 D) \text{ ohms}$$

$$d/D = 0.55$$

$$b/d = 1.5. \quad (4)$$

General conditions for all charts are:

$$B \approx (b + D/2)$$

$$\tau < d/2.$$

The usual precautions for fabricating high-Q coils must be observed. A protective silver plating on the surface of the copper wire and shield is recommended. A silver-clad or solid silver conductor increases the Q about 3 per cent over that for silver-plated copper. A tinned conductor can be substituted for a silver-plated one up to about 100 mc without seriously affecting the Q. The shield should not have a seam parallel to the axis; any seam must be effectively soldered for a low-resistance joint. It is desirable to carry the lower end of the coil over to the side of the shield as directly as possible. A minimum amount of dielectric material should be used in the coil form, and it should be eliminated entirely when possible.

Region of Usefulness

The region where straight coaxial resonators are preferable is separated from that where the use of a helical inner conductor is desirable by a rather broad transition zone. A resonator with about three turns lies within the transition zone. On the chart of Fig. 3 the upper dashed line represents this boundary. In the region near and above the line a straight coaxial resonator should be considered, while below it the helical one is usually preferred. The choice is affected by the shape factor. A coaxial resonator is long and relatively small in diameter. In the helical resonator the length is not much greater than its diameter.

This number, $N = 3$, can be derived from either of two basic concepts. The first is the locus of points where equal unloaded Q vs frequency is obtained with the two types of resonators having equal volumes. For the straight inner conductor type[4] the theoretical Q is derated about 10 per cent for a practical working value. This is compared with (22) for the helical type. The second basic concept is the limitation that $\tau < d/2$, or the pitch of the helix be less than its radius (other-

[4] F. E. Terman, "Radio Engineers Handbook," McGraw-Hill Book Co., Inc., New York, N. Y., 1st ed., p. 192; 1943.

wise it almost ceases to be helical). When $b/d=1.5$, $N=bn=b/\tau>2b/d=3$ turns. The result in either case is

$$Q_u f_0^{1/2} < 32{,}000 \text{ or } N > 3 \text{ turns}, \quad (5)$$

as the more desirable criterion for the helical resonator.

The demarkation between the relative desirability of a helical resonator vs a lumped-constant tuned circuit is also broad. The lower dashed line on Fig. 3 and the point marked "lower limit" on Fig. 4 are drawn for the condition that the diameter of conductor be greater than five times the skin depth (otherwise the helical-resonator Q will be lower than predicted by the charts). If the alignment on Fig. 4 lies above the "lower limit" point an LC circuit may be preferable. The skin depth is[5]

$$\delta = 2.60 f^{-1/2} \times 10^{-3} \text{ inch}. \quad (6)$$

Utilizing (1) and (3) there results

$$Q_u f_0^{1/4} > 385 \text{ or } f_0^{3/4} D > 7.75, \quad (7)$$

as the condition for the helical resonator being more desirable than the LC circuit. Below this region, for a given volume and Q it becomes advantageous to use fewer turns of larger diameter conductor along with an added capacitor for resonance.

Example

Design a resonator with $Q_u=1000$ at resonance frequency $f_0=10$ mc. By the charts and formulas, $D=6.3$ inches and $N=30$ turns, $\tau=0.174$ inch per turn and $Z_0=1550$ ohms, provided $d/D=0.55$ and $b/d=1.5$, approximately. Let $n=6$ turns per inch in round numbers. Other dimensions are $d=3.5$ inches, $b=5$ inches, $B=5+(6.3)/2=8.2$ inches. The conductor size can be No. 14 to No. 10 B&S gauge ($d_0=0.064$ to 0.102 inch) corresponding to d_0/τ ranging from about 0.4 to 0.6.

The power rating of the resonator can be estimated by use of (32) or (33). Suppose a matched generator is used and a doubly-loaded Q of 100. Assuming a dissipation factor $k=0.4$ watt per square inch, then the generator can have an available power of $P_m=460$ watts. Of this, 20 per cent, or $P_c=92$ watts, is dissipated in the cavity.

If the generator is zero- or infinite-impedance and the singly-loaded Q is 100, the loss in the resonator is 10 per cent. A generator rated at 920 watts can be accommodated.

Experimental Results

The properties of resonators designed in accordance with the chart have been checked experimentally in a considerable variety of models. Fig. 5 shows unloaded Q vs quarter-wave resonance frequency for 26 resonators in 4 size groups. Mechanical tolerance in construction resulted in deviations of up to 5 per cent from the standardized proportions. There was no particular uniformity of conductor material or surface condition. Silver-clad copper, tinned copper, bare copper, and enameled copper were used according to ready availability in the appropriate diameter. The shields consisted of lengths of commercial copper tubing, with no special attention given to surface condition except for the smallest sizes, which were silver plated.

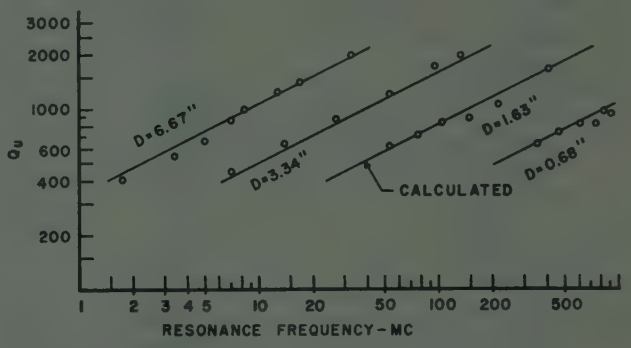

Fig. 5—Comparison of measured and computed Q.

Nearly all of the helices were wound on grooved tubular forms of Rexolite 1422 having wall thicknesses of one-sixteenth to one-quarter inch, depending on the depth of groove required. The helices consisting of only a few turns of heavy conductor were self supporting. In one case, a dielectric-supported helix (shown on the graph in Fig. 5 at $f_0=33$ mc, $Q_u=2000$) was duplicated without the form for comparison. The self-supported helix exhibited about 10 per cent higher Q and 3 per cent higher resonance frequency.

Tests were made to check the predicted optimum d/D ratio and the accuracy of the Q indicated by (22). The plot in Fig. 6 shows typical data, in this case for $b/d=1.5$ and $d_0/\tau=0.5$. Ordinates give the ratio of the measured Q to the predicted value. The curve confirms that the maximum Q occurs when d/D is in the vicinity of 0.55. The maximum value of measured Q exceeds the calculated value by about 8 per cent. This is within the normal expected tolerance of predicted Q, due to variations of materials and construction.

The Q calculated by (1) is based only on the frequency at which the helix is used, and is not restricted to the special case of quarter-wave resonance. The prediction should be valid also for the helix as a lumped inductor, where the electrical length is quite small. To test this, a typical helix was tuned downward in frequency by external capcitance. Some difficulty was experienced in finding capacitors having a Q much higher than that of the helix. The desired tuning range with reasonable losses was covered by a composite array of transmitting-type vacuum capacitors and handmade parallel-plate air dielectric trimmers. The Q vs frequency is shown in Fig. 7.

[5] "Reference Data for Radio Engineers," *op. cit.*, p. 129.

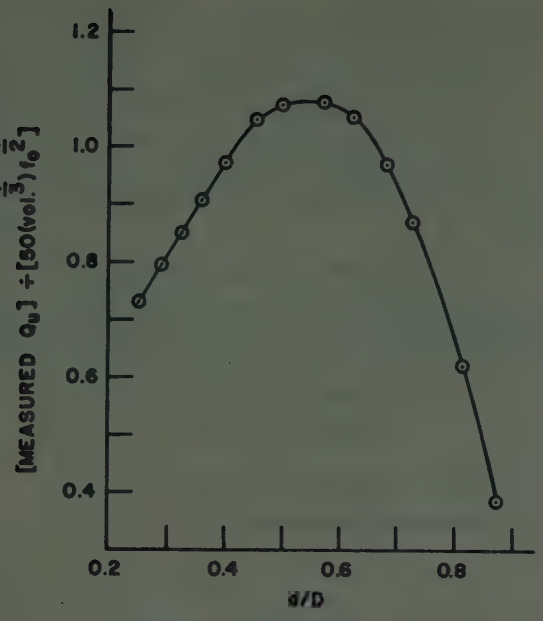

Fig. 6—Test for optimum coil-to-shield diameter ratio.

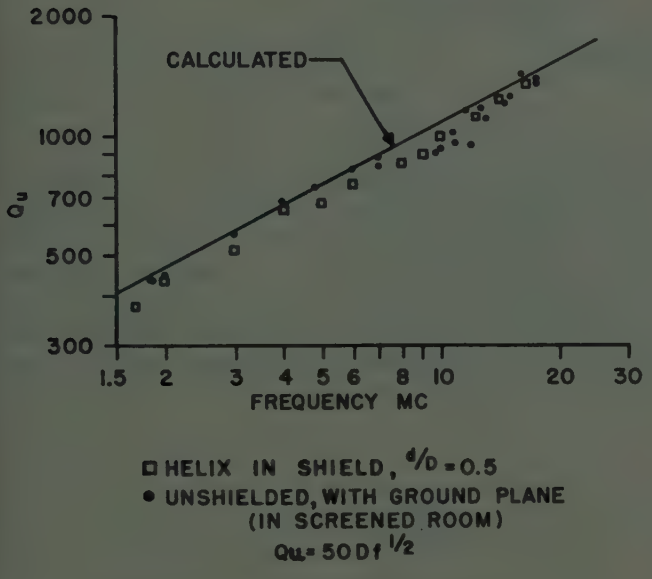

Fig. 7—Measured Q of helix below quarter wave (capacitance tuned).

The data seem to confirm the predicted square-root-of-frequency variation in Q. The scattering of points is accounted for by losses in the external capacitors and associated leads. The uppermost points are for quarter-wave resonance with no capacitor. Those down to 12 mc were obtained by using closely-spaced copper tabs as capacitors. Below 12 mc the effect of introducing the larger, lower-Q capacitors is evident.

Theory

This elementary theory of the quarter-wave helical resonator makes no pretense of being rigorous. Rather, it is directed merely toward developing simple equations and charts for the satisfactory design of resonators.

It has been found to be practical to compute the inductance and capacitance per unit length of the resonator coils as if they were very long. The inductance of a long solenoid[6] as modified by the effect of the shield[7] is

$$L = 0.025n^2d^2[1 - (d/D)^2] \ \mu\text{h per axial inch.} \quad (8)$$

On the basis of measurements of the resonance frequency and characteristic impedance of various resonators, it appears that the effective capacitance is somewhat greater than that of two simple coaxial cylinders. Also, the electrical length of the helix is 5 to 7 per cent less than quarter wavelength. These are attributed in part to the self capacitance of the coil and the fringing field at the top of the coil. An empirical value is:

$$C = 0.75/\log_{10}(D/d) \ \mu\mu\text{f per axial inch.} \quad (9)$$

The velocity, and hence the axial length, of the resonator helix are:

$$v = f_0\lambda = 1000\,(LC)^{-1/2} \text{ inches per microsecond,} \quad (10)$$

$$b = 0.94\lambda/4 = 235f_0^{-1}(LC)^{-1/2} \text{ inches.} \quad (11)$$

Substituting (8) and (9) in (11):

$$1/\tau = n = \frac{1720}{f_0D^2(b/d)(d/D)^2}\left[\frac{\log_{10}(D/d)}{1 - (d/D)^2}\right]^{1/2} \text{ turns per inch,} \quad (12)$$

$$N = nb = \frac{1720}{f_0D(d/D)}\left[\frac{\log_{10}(D/d)}{1 - (d/D)^2}\right]^{1/2} \text{ turns.} \quad (13)$$

The characteristic impedance is

$$Z_0 = 1000(L/C)^{1/2} = 235{,}000(bf_0C)^{-1}$$
$$= \frac{0.31 \times 10^6 \log_{10}(D/d)}{f_0D(b/d)(d/D)}$$
$$= 183nd\{[1 - (d/D)^2]\log_{10}(D/d)\}^{1/2} \text{ ohms.} \quad (14)$$

Unloaded Q

The losses consist of conductor losses[8,9] in the winding and shield, and dielectric losses. The latter are quite small in coils of good design, but are not readily computed. The references noted give formulas for the ac resistance of a straight conductor, the proximity effect due to current in nearby turns and resistance due to currents in the shield. For copper helix and nonmagnetic shield

[6] "Radio Instruments and Measurements," Bureau of Standards circular C74, U. S. Government Printing Office, Washington, D. C., p. 252; 1937.
[7] F. E. Terman, *op. cit.*, p. 129.
[8] "Reference Data for Radio Engineers," *op. cit.*, p. 131.
[9] F. E. Terman, *op. cit.*, pp. 78–80, 129.

$$R_c = (n\pi d)\phi f^{1/2} d_0^{-1} (1/12) \times 10^{-3}$$
$$= (0.083 \times 10^{-3})(\phi/nd_0) n^2 \pi d f^{1/2} \text{ ohms per axial inch,} \quad (15)$$

$$R_s = \frac{9.37 n^2 b^2 (d/2)^4 (1.724f)^{1/2}}{b[D^2(b+d)/8]^{4/3}} (\rho_s/\rho_{cu})^{1/2}$$
$$\times 10^{-4} \text{ ohms per axial inch.} \quad (16)$$

The unloaded Q is given by:[10]

$$Q_u = \beta/2\alpha = 2\pi f_0 L/(R_c + R_s), \quad (17)$$

the last form being the value when dielectric losses are neglected. Note that the Q is the same as that approached by a lumped LC resonant circuit as the losses in the capacitor and connections approach zero.

For the resonator with copper coil and copper shield,

$$Q_u = 600 \frac{(d/D) - (d/D)^3}{(\phi/nd_0)(1 + R_s/R_c)} D f_0^{1/2}. \quad (18)$$

Instead of determining the proximity factor ϕ for each case, it is sufficiently accurate to write:

$$\phi/(nd_0) = \phi\tau/d_0 = 3.7, \quad (19)$$

when d_0/τ lies within the range given in the conditions for (1).

From these there can be derived two practical formulas for Q with accuracy of about ± 10 per cent when $0.45 < (d/D) < 0.6$ and $(b/d) > 1.0$.

$$Q_u = 220 \frac{(d/D) - (d/D)^3}{1.5 + (d/D)^3} D f_0^{1/2}, \quad (20)$$

$$Q_u = 50 D f_0^{1/2}. \quad (21)$$

The Q in these formulas has been arbitrarily reduced 10 per cent below the theoretical value to allow for imperfect surface conditions of the conductor. Tabulation of errors of (20) vs (18) (reduced 10 per cent) for the ranges of d/D and b/d listed for (20) shows them to give substantially equal results, and similarly for (21) vs (20).

A useful relationship is that of Q_u and volume of shield. When $0.4 < d/D < 0.6$ and $1.0 < b/d < 3.0$;

$$Q_u = 50 \text{ (vol)}^{1/3} f_0^{1/2}. \quad (22)$$

Proportional Relationships

The energy considerations of resonant lines are given in a previous reference.[3] Suppose a series of resonators is considered that has various sizes and resonance frequencies, but in which the geometrical porportions are all identical. Consequently, the design parameters d/D, b/d, and $nd_0 = d_0/\tau$ are the same for all the resonators. Let the input and output loadings be equal or matched, so that there is no mismatch loss.

Then the following proportionalities and equations can be written:

$$Q_u \propto f_0^{1/2} d, \quad (23)$$
$$P_c = 2P_m Q_d/Q_u, \quad (24)$$
$$\text{(temp rise)} \propto P_c/d^2, \quad (25)$$
$$\text{(vol)} \propto d^3. \quad (26)$$

Various combinations can be made of the above expressions:

$$\text{(temp rise)} \propto P_m Q_d (\text{vol})^{-1} f_0^{-1/2}. \quad (27)$$

The voltage gradient at the open-circuited end, and similarly between turns at the short-circuited end, is:

$$\text{(volt grad)} \propto V_{oc}/d = Z_0 I_{sc}/d$$
$$\propto (P_m Q_d)^{1/2} [(\text{vol}) f_0]^{-1/2} \quad (28)$$

For a given P_m and Q_d there results:

A) temperature rise constant;

$$\left.\begin{aligned} &\text{(vol)} \propto f_0^{-1/2} \\ &Q_u \propto f_0^{1/3} \\ &\text{(volt grad)} \propto f_0^{-1/4} \end{aligned}\right\} \quad (29)$$

B) unloaded Q constant;

$$\left.\begin{aligned} &\text{(vol)} \propto f_0^{-3/2} \\ &\text{(temp rise)} \propto f_0 \\ &\text{(volt grad)} \propto f_0^{1/4} \end{aligned}\right\}. \quad (30)$$

The proportionalities in (29) and (30) are plotted in Fig. 8. A certain frequency ratio $f_0/f_1 = 1.0$ is shown, above which the temperature rise is indicated as constant, while the relative volume, voltage gradient and Q_u are plotted vs frequency ratio. In this region the unloaded Q is adequate, but temperature rise is the limiting factor. The volume is chosen according to the power rating P_m and the loaded Q.

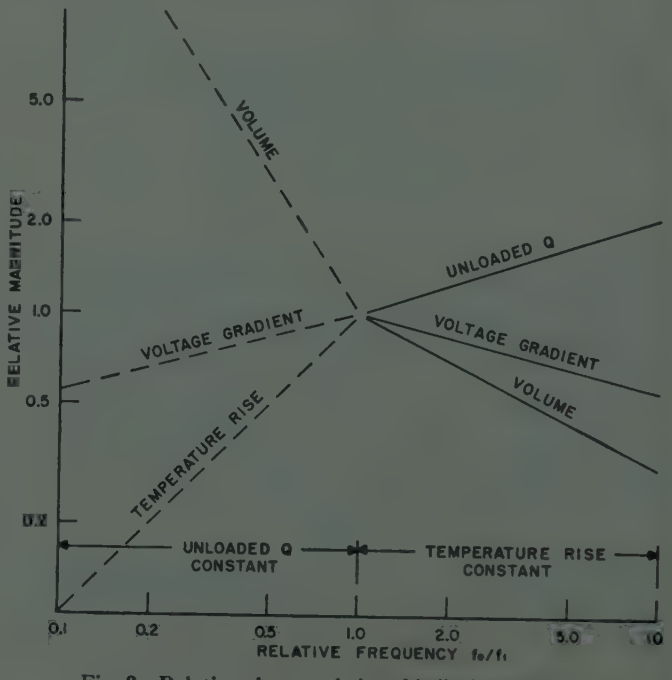

Fig. 8—Relative characteristics of helical resonators.

[10] "Reference Data for Radio Engineers," *op. cit.*, pp. 553, 575.

Below the frequency ratio $f_0/f_1 = 1.0$ the unloaded Q is the limiting factor, because it cannot be allowed to decrease indefinitely. The lower the unloaded Q the greater the dissipation loss. Then the efficiency of the system would become lower than is desirable, or, in other words, the transducer loss would be excessive. In this region, as shown in Fig. 8, the volume increases rapidly.

Power Rating

The power-handling capacity can be estimated by use of (24) and the dissipation from the surface of the shield:

$$P_c = k \text{ (shield area) watts.} \tag{31}$$

When $d/D = 0.55$, $b/d = 1.5$ and $B = b + D/2$ the entire shield area is 5.8 D^2. Then when the top and bottom of the shield are closed and no ventilating holes are provided

$$P_m = 145kD^3f_0^{1/2}/Q_d \text{ watts.} \tag{32}$$

The value of k depends on the design and materials of the resonator. A conservative value is believed to be $k = 0.4$ watt per square inch.

For a zero- or infinite-impedance generator properly loaded by the cavity and its load:

$$P_s = 290kD^3f_0^{1/2}/Q_s \text{ watts.} \tag{33}$$

Correction

R. S. Colvin, of the Radio Propagation Laboratory, Stanford University, Stanford, Calif., has brought the following correction to the attention of Peter D. Strum, author of "Considerations in High-Sensitivity Microwave Radiometry," which appeared on pages 43–50 of the January, 1958, issue of Proceedings.

In Table I, page 46, the last line, right-hand column, should read "$1/\sqrt{2}$," not "$1/\sqrt{\pi}$," as shown.

Digital Rate Synthesis for Frequency Measurement and Control*

T. J. REY†

Summary—Digital rate synthesis is a transformation of harmonic synthesis (beat methods) from the frequency to the time domain; the synthesis of harmonics is replaced by pulse techniques.

The signal whose period is to be measured or controlled is in the form of a pulse train that has the repetition rate X. A single reference source drives a rate generator which consists of one or more dividing stages in fixed cascade; the output of the generator is a sequence of nonuniformly spaced pulses whose average repetition rate AS is known from the independently controllable connection between the individual stages and their output bus.

A rate difference detector compares the rates X and AS. The smoothed detector output has the proper sign and serves to indicate the magnitude of the difference or to reduce the difference in a closed loop, for example, by controlling a tuning motor.

The range of direct operation is limited by pulse techniques, but digital and harmonic synthesis can be combined with division and with phase-lock methods to stabilize an oscillator over a practically unlimited band of frequencies, the precision and purity approaching that of the reference source.

I. Background

THE study of digital rate synthesis (DRS) for frequency control was stimulated by limitations in conventional methods, although applications to date have been in the related fields of computing systems[1] and of motor speed control[2] only. (DRS in relation to computing techniques is discussed briefly in Appendix C.)

Conventional methods of frequency control fall into two groups, "harmonic synthesis" and "gated counts," respectively.

An example of the former[3] is the single-crystal frequency synthesizer that selects and combines harmonics and subharmonics of the crystal frequency to provide one of many possible outputs. Although crystal precision is preserved, spectral purity suffers from spurious signals generated in the combining mixers, the more so the greater the number of combinations. Spurious levels are reduced by using the selected output to lock the phase of a variable frequency oscillator (VFO), but further difficulties arise unless the VFO is pretuned closely enough; this often proves to be impossible by conventional (*e.g.*, mechanical) means.

The gated count is well known for the measurement of periodic phenomena in the form of pulse series. The number of pulses N in a prescribed period T is counted and displayed repeatedly. The pulse repetition rate is:

$$\frac{N_{+\epsilon}}{T}, \qquad 0 \leq \epsilon < 1;$$

the error ϵ stems from the integral nature of counting and the random phase between the unknown and the counting periods. A VFO can be tuned, manually or automatically, toward a prescribed frequency with the aid of a gated counter.

A large value of T aids precision, but requires a large maximum count and affects the system stability adversely. Automatic frequency control by a gated counter[4] further necessitates the subtraction of the actual from the desired count, the conversion of the numerical difference to a control voltage and the holding of that voltage, all in a properly timed cycle.

II. The Principle of Digital Rate Synthesis

In DRS, the stress is on the counting rate rather than on the Fourier frequency aspect of periodic phenomena; yet it can be compared both with harmonic synthesis and with the technique of the gated count. Thus, the selection and mixing of harmonics is replaced by the selection and superposition of repetition rates; again, a difference rate is measured rather than the count that accumulates in a known interval. Simplicity, resolution, range width and rapidity of response are enhanced accordingly.

Fig. 1 and Fig. 2 illustrate the principle. The uniform pulse train X represents the signal whose period is to be measured or controlled, and requires a pulse-forming circuit if the signal is not of suitable form.

Pulse train AS consists of nonuniformly spaced pulses; their average repetition rate is AS, where S is the frequency of the reference source and A is the number $a_0.\, a_1 a_2 \cdots a_n$. The known digits $a_0, a_1 \cdots a_n$ are set up in the rate generator which comprises dividing circuits in fixed cascade connection. The output rate AS is obtained by selecting and superposing pulse trains available at the various stages by means of switches or gates which determine the number A, digit by digit. The superposition guarantees a minimum for the spacing of the pulses,

* Original manuscript received by the IRE, March 13, 1958; revised manuscript received, March 15, 1959. A summary of this paper was presented at the URSI meeting, Washington, D. C., May 23, 1957. The work reported was performed at the Lincoln Laboratory, Massachusetts Institute of Technology, with the joint support of the U. S. Army, Navy, and Air Force.

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[1] M. A. Meyer, "Digital techniques in analog systems," IRE Trans. on Electronic Computers, vol. EC-3, pp. 23–29; June, 1954. See also M. A. Meyers, *et al.*, "An operational-digital feedback divider," IRE Trans. on Electronic Computers, vol. EC-3, pp. 17–22; March, 1954.

[2] C. I. Jones and K. Geohagen, Westinghouse Electrical Corporation, private communication.

[3] R. L. Craiglow and E. L. Martin, "Frequency control techniques for single sideband," Proc. IRE, vol. 44, pp. 1697–1702; December, 1956. See also H. J. Finden, "The frequency synthesizer," *J. IEE* (London), vol. 90, pp. 165–177; December, 1943.

[4] Northern Radio, "Variable Master Oscillator," Type 173, Model 1.

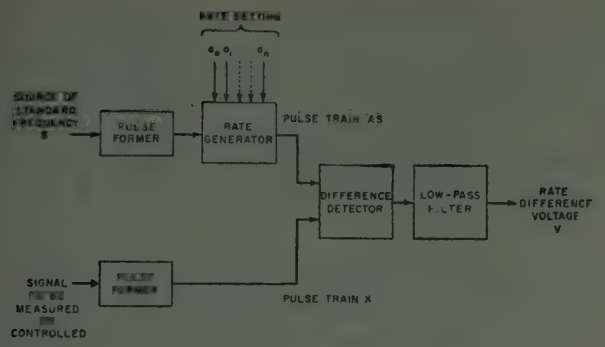


Fig. 1—System schematic.

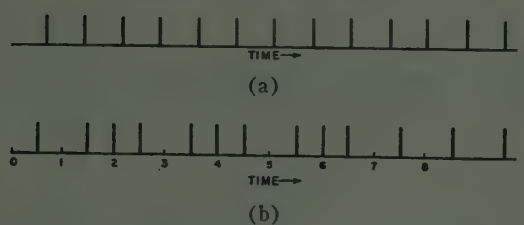


Fig. 2—Pulse trains: (a) train X, (b) train AS.

which is nonuniform, in general. Rate generators are discussed further in the next section.

The rates X and AS are compared in the detector; the smoothed detector output ideally is a dc proportional to $X-AS$, in both magnitude and sign. The proportionality holds near balance, although saturation occurs at large differences.

For measurements, the detector output can be displayed or recorded and/or used for control of the rate setting A by means of selector switches which operate on the digits a_i.

For control, the rate difference voltage serves as a wide-band error voltage; *e.g.*, if X is the frequency of an oscillator, the error voltage V operates a tuning device which reduces the tuning error. The residue can be reduced to zero by phase locking. DRS can be applied to frequency ranges exceeding convenient pulse rates by feeding the detector with multiples or submultiples, or by combining it with harmonic synthesis.

The further dicussion of the component blocks is facilitated by using the concepts current in digital computer design (Appendixes A and B), and by dealing with only a few of the many possible arrangements.

III. Rate Generation

A. Counting Rates

Rate synthesis is based on the simple properties of counters; both of these will be considered briefly.

A counter stage whose successive counts are 0, 1, 2, $\cdots$, N-1, 0, 1, $\cdots$, etc., is said to count "modulo N" and to have N possible "states." Given a counter input of rate S, each state changes at the rate S/N. When a stage of modulus M is fed at the rate S/N, every one of its states changes at the rate S/MN. Similarly, n cascaded stages, all of modulus N, generate the lowest rate $N^{-n}S$ from the last stage. Moreover, pulses can be derived from any stage whenever any one of its states arises. Excluding one state, say zero, it follows that the individual stage can deliver 0 or 1 or $\cdots$ or $(N-1)$ pulses for every N pulses fed into it. As will be shown next, any or all of these contributions from the n stages can be combined with each other and with the pulse train of rate S without losing a pulse, hence any average repetition rate in the range 0, $N^{-n}S$, $(2-N^{-n})S$ can be obtained. The combined rates have the shortest common period N^n/S, hence the average is always obtained in that period, which may be quite short.

The requirement that no pulse be lost in combining the contributory rates is met on noting that the addition of unity to an integer in digital representation increases one digit at most.[5] It follows that the pulse contributions must be taken when the relevant state is arising and not at its cessation. Where delay times in the generator are negligible, all changes of state coincide with a pulse of the train S, hence the latter must be shifted if it is to be combined with the counter contributions. A suitable delay is $1/2S$; the intervals between the pulses in the compound train are then equal to or integral multiples of $1/2S$, in accordance with the fact that the average value of the combined rate is always less than $2S$.

The combination rule can be stated thus: Given a fixed frequency S, the instants allocated to the pulses of average rate AS are spaced by $1/2S$; the instants allocated to the contribution of any one digital place are those left after deducting for any higher digital places and for every Nth pulse.

N is the radix or base of the digital place under consideration, hence the rule also applies to mixed radix representation of the number A.

B. Binary Generator

A cascade of triggers forms a binary counter ($N=2$). Reference to Fig. 3, in which $n=4$, shows that the "beginning" element, switch contacts, gates, and a time delay complete the rate generator schematic. The $\div 2^1$ trigger is fed with the pulse train S after its polarity has been reversed; the $\div 2^i$ trigger is fed from the $\div 2^{i-1}$ trigger for $i>1$. The n binary stages form a counter modulo 2^n.

When the ith trigger goes to 1, the beginning element at its output delivers a pulse to the switch contact a_i; this is open if $a_i=0$ and no contribution is made to the output. If $a_i=1$, a pulse is delivered to the coincidence gate whenever the ith trigger goes to 1. As shown in Fig. 3, the coincidence gate is also fed with the original pulses S for the purpose of reshaping the differentiated trigger outputs. This renders their performance less critical, but the reshaping pulse may have to be delayed to match the lags of the trigger and beginning circuits.

[5] Example: In decimal notation, given 3 digits: in 909+1=910 the digit 0 increases to 1, in 999+1=000 no digit increases.

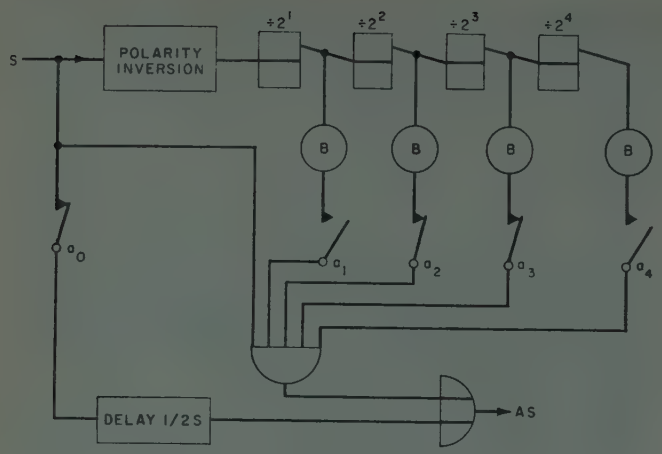


Fig. 3—Binary rate generator.

The switch contact a_0 allows S to be added with the aid of the delay unit $1/2S$ and the "and" gate.

One "beginning" element can be shared between two or more triggers by rearranging the circuit somewhat. Also, the polarity inversion and delay units can be replaced by feeding the rate $2S$ to a trigger followed by two "beginning" elements. Switches can be replaced by gates for control by electric signals.

C. Decade Generator

The decimal notation is desired in most applications; a binary generator can be modified accordingly, or it can be replaced by cascaded stages of decade rings.

An example of such rings is the decade counter tube of the multicathode type. The decimal digit a_i is set up by joining a_i cathodes of the ith tube; *e.g.*, by a cumulative switch (see Fig. 4). The selection of a_i states in the natural order is not necessary; the nonuniformity of the pulse spacing in the output is reduced to 2:1 (as in the binary case) if the cathodes are joined as indicated in the pulse-spacing scheme below.

Cathode	0	1	2	3	4	5	6	7	8	9
Digit a_i										
1						×				
2				×				×		
3			×			×			×	
4			×		×		×		×	
5		×		×		×		×		×
6	Complementary with 4, etc.									

More economical designs are offered by techniques that may be termed "pseudodigital." A sawtooth generator is triggered by every tenth pulse of the input, and delivers a sawtooth and a pulse at a tenth of the input rate. The contribution of a_i pulses is taken from a coincidence circuit fed with the input and an enabling voltage; the latter consists of the sawtooth and a bias set according to the chosen digit a_i. A two (decimal) digit generator of this type is shown in Fig. 5. It will be noted that every stage operates at its fixed rate, and this fact can be used to enhance reliability.

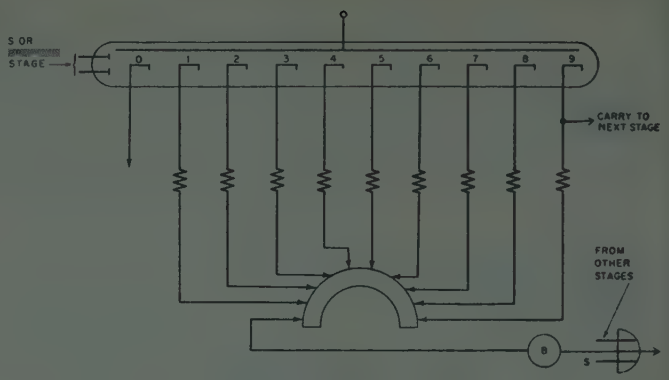


Fig. 4—Dekatron for rate generation.

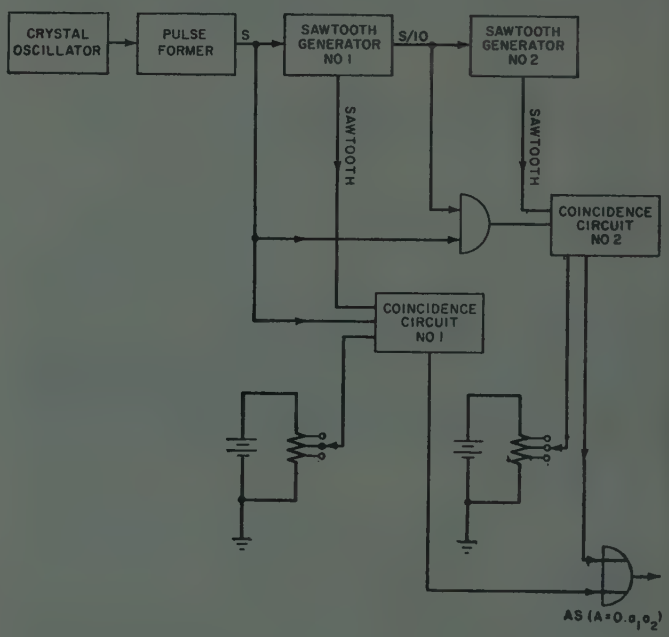


Fig. 5—Two decade generator (pseudodigital).

IV. Detection

A. Superposition and Pairing-Off

The basic method of rate error detection is superposition (see Fig. 6). When a unidirectional current pulse is repeated X times per second, the dc component of the pulses is proportional to X; thus, if trains X and AS are superposed after inverting the polarity of AS, for instance, and then passed through a low-pass filter, this supplies a dc difference voltage V (Fig. 6). In practice, the individual pulses are not identical and V fails to vanish when $X = AS$. This zero error is reduced greatly if the filter is fed at the rate difference $X - AS$ rather than with the rates X and the polarity inverted AS. The rate difference is generated by a pairing-off circuit [Fig. 7(a)] comprising a bistable trigger or flip-flop and two coincidence gates. Pulses X are applied to one control terminal and pulses AS to the other. For definiteness, it is convenient to assume tubes in the flip-flop and nega-

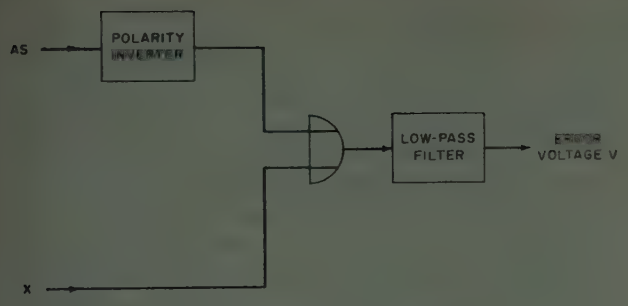


Fig. 6—Detection by superposition.

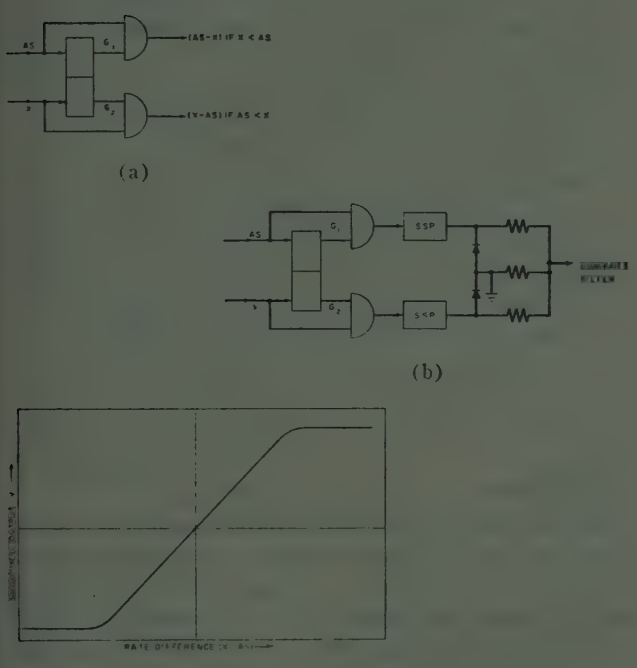


Fig. 7—Simple rate difference detection: (a) pairing-off circuit, (b) simple detector, (c) detector characteristic.

tive-going pulses in the pulse trains applied to their grids. The plates are coupled to AND gates G_1 and G_2. These are also fed with the pulses in such a way that the gate G_1 has an output if the flip-flop is at "one" when an X pulse arrives at the flip-flop, whereas gate G_2 has an output if the flip-flop is at "zero" when an AS pulse arrives; otherwise the gates have no output. Because of finite response speeds, the coincidence of the present X or AS pulse and the slightly earlier trigger state actuate the gates.

If it is assumed, for the moment, that the pulses are uniformly spaced in each train and that these have equal repetition rates, no pulse is emitted if the trigger is at "zero" prior to the arrival of an X pulse; similarly, there is no emission if this is at "one" prior to an AS pulse arriving. However, a pulse is emitted if X exceeds AS and continues to be emitted at the difference rate. (One error pulse is generated if the flip-flop is at "zero" when an AS pulse arrives or if it is at "one" when an X pulse arrives. This difference pulse is false, but it is not repeated.)

If the difference output is to be single-ended, the polarity of the output of one of the gates, G_1 or G_2, must be reversed. This can be done with the aid of two single-shot pairs (SSP), each of which delivers a balanced pulse when it receives an input. The SSP outputs are combined in a mixing unit [see Fig. 7(b)], a simple form of which is a resistive pad fed from the SSP with the aid of dc restoring diodes. The mixer output is a train of pulses, the repetition rate is the difference rate and the polarity is the sign of the frequency error. The dc component is the desired error signal. The characteristic [see Fig. 7(c)] saturates at a level proportional to the peak value of the pulses from the SSP and at a difference rate whose period is about equal to the width of the pulses from the SSP.

The detector could malfunction whenever an X pulse almost coincides with an AS pulse. Such pairs are suppressed in a simple "pulse antifouling circuit" (Fig. 8), which tests for coincidence of the broadened pulses in one with those of the other; the AND gate output controls the anticoincidence gates fed with the delayed but unbroadened pulses, as required for well-spaced outputs X' and $(AS)'$ that conserve the difference rate $X-AS$.

The nonuniformity of the synthetic pulse train AS has been ignored so far; its nature and implications will be considered next.

B. Uneven Spacing

The synthetic rate AS is generally subject to nonuniform spacing [*e.g.*, Fig. 2(b)]. Hence, even when the rate difference is zero, the simple detector of Fig. 7(b) is not quiescent, and its mean output fails to vanish unless the output pulses are matched perfectly. The problem is understood better on considering the response of a difference counter[6] fed with X and AS [or X' and $(AS)'$] (see also Appendix B); when $X=AS$, the count vacillates by a certain amount. The maximum Δy of these excursions has been estimated as a function of the number of digits n in A, with the following result.

The Binary Case

n	2	4	8	10	14	16	20
Δy	1	2	2	3	3	4	4
M	1	2	2	2	2	3	3

The last row (M) denotes the least number of binary stages in the difference counter which are required to accommodate the difference count Δy.

The Decimal Case

n	1	2	3	4	5
Δy	3	5	8	10	13
M	3	3	4	4	4

[6] K. H. Barney, "The binary guantzer," *Elec. Engrg.*, vol. 68, pp. 962–977; November, 1949.

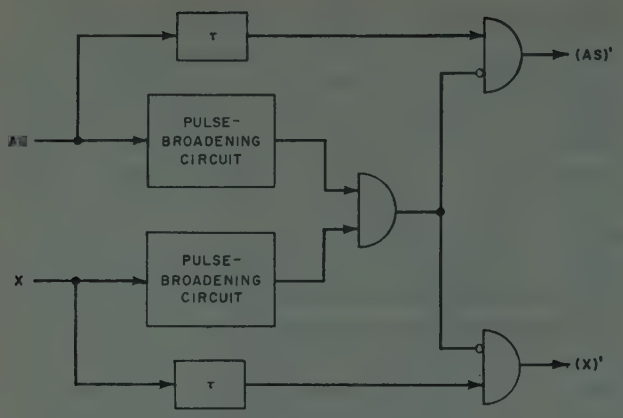


Fig. 8—Pulse antifouling circuit.

Synthesis of A is assumed in the natural order, and with the possible addition of 1.

The difference counter cannot register Δy correctly unless overflow is prevented. The most positive number it can indicate is of type 011, *i.e.*, a "zero" in the trigger of greatest digital significance and a "one" in all other triggers; similarly the most negative number is of type 100. As shown in Fig. 9, the counter is guarded against overflow by means of coincidence gates G_3 and G_4 that sense the extremal counts, and by anticoincidence gates G_5 and G_6; the AS pulses are blocked from the counter when the count 011 has been reached by means of G_5, and G_6 blocks the X pulses when the count 100 has been reached.

The discussion of the rate difference detector will now be resumed.

C. The Balanced Detector

The desired zero output in the case $X = AS$ can be approximated in several ways; it is assured by quiescence on applying the principles of subsections B and C above.

The circuit is shown as Fig. 10, and differs from that of Fig. 9 only in the gates G_1 and G_2; gates G_3 and G_4 are now indicated by the box labeled "Overflow Sensing Gates." When the difference counter has reached its positive maximum (due to an X pulse) and the next pulse is an X, gates G_2 and G_6 divert this from the counter to the relevant SSP and thence to the output. The first AS pulse subtracts unity from the maximum count but does not reach the output. The circuit is symmetrical with regard to the two pulse trains, except for the mixer that feeds the low-pass filter. This is also true of the simple detector [see Fig. 7(b)], but the desired balance is achieved by quiescence rather than by critically adjusted components and operating conditions. The detection characteristic [see Fig. 7(c)] must pass through the origin now, but with abrupt change of slope if there is any SSP unbalance. In the close vicinity of the origin, the actual output approximates a train of unidirectional impulses.

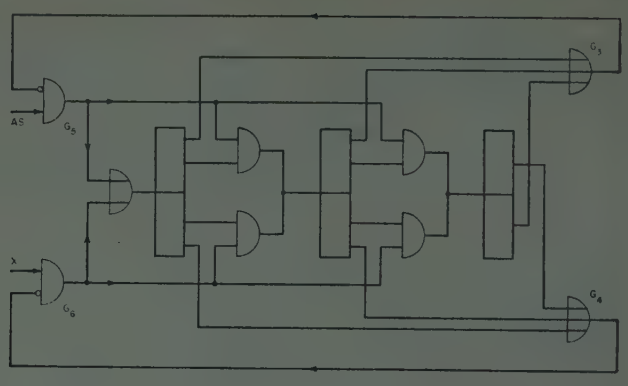


Fig. 9—Difference counter with overflow guard.

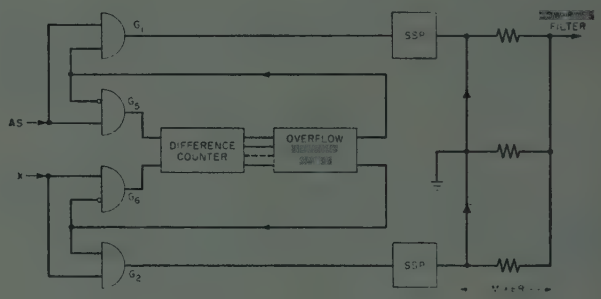


Fig. 10—Balanced difference detector.

V. System Properties

A. Resolution

The resolution of the above detection process is not limited by the cycle of a "clock" as in the gated count technique. However, a time equal to the reciprocal of the rate error must elapse before this becomes known; *e.g.*, if X exceeds AS by 10^{-1} cps, the SSP that contributes positively fires once every 10 seconds, on average. Because of nonuniform spacing, a nonrecurring group of pulses ($\leq \Delta y$) is emitted, and the firing rate is modulated at a rate depending on $a_n 10^{-n} S$ (the lowest contribution to AS). A graver effect stems from detector malfunction by badly spaced pulse pairs; although a simpler circuit [see Fig. 7(a) or Fig. 8] than the balanced detector can be assigned to deal with bad pairs, only one of the partners will still be suppressed occasionally. Resolution is limited to the extent that faulty suppressions have a (fluctuating) mean in a time of the order of the post-detection smoothing period; the effective mean should be very small when pulse trains X and AS are randomly related and when the circuits are well balanced.

B. The Closed System

A closed-loop control system will now be considered. The detector output is the error signal[7] and controls the tuning motor of a VFO for frequency control, or the settings of the digit switches in the rate generator for the automatic measurement of the rate X.

[7] A "fine control" can be provided by a bias in series with the error signal.

The system is of position-control type, since the mean error signal is proportional to the position error (of tuning motor) near balance. Balance is independent of the initial error, and convergence is speeded up if the low-pass filter is of the swinging-choke type. However, balance tends to be unstable owing to the intermittent nature of the control signal; stabilization may be provided by hysteresis (by Coulomb friction) or, in the case of a measurement loop, by the discrete nature of A.

A superior method of stabilization is available for frequency control, since the frequency AS is always some integral multiple of the lowest contributory rate that can be drawn from the rate generator. A system of this type is illustrated by Fig. 11, in which the VFO tuning motor is driven by the error voltage. A loop for locking the VFO phase is also provided; the uniform pulse train of rate $10^{-n}S$ (or $2^{-n}S$ in binary synthesis) serves as the reference signal for periodic clamping of the controlled oscillation; the clamped voltage controls the frequency modulator (*e.g.*, a reactance tube) across the VFO tank circuit. The properties of a well-designed phase loop are such that both the stability and the spectral purity of the reference signal S are preserved in the locked oscillator. Jitter in the reference rate ($10^{-n}S$) must be kept low by retiming with the signal S. The design of the phase loop is simplified further by restricting its pull-in range to a small tuning error.

The DRS loop is quiescent at lock unless a simple rate error detector is used or activity arises from badly

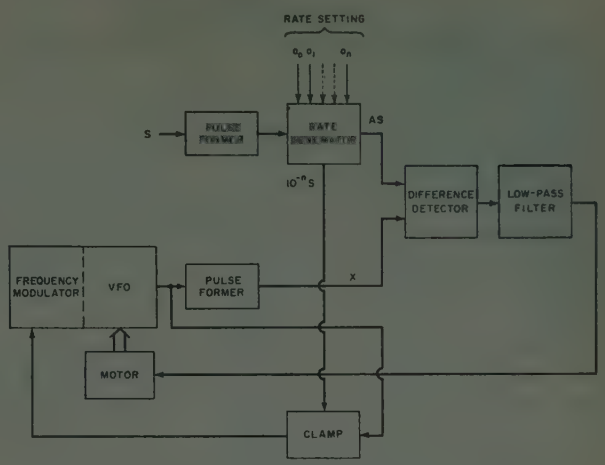
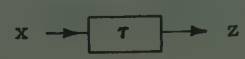
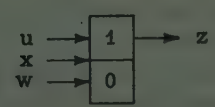
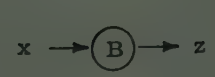


Fig. 11—Frequency control system with phase stabilization.

spaced pairs in the now-phase-related pulse trains X and AS; the DRS loop can be opened at lock by using the fact that ac is then absent from the output of the phase clamp.

Appendix A
Logical Symbols

Logical symbols are the elements of circuits which operate in on-off fashion, such as 0 or 1 volt (this implies step functions, or impulses of finite width). The symbols represent functions of Boolean algebra and/or of time.

Name	Symbol	Function	Note
OR gate		$z=(x \text{ or } y)=(x \vee y)$	Output exists when there is at least one input
AND gate, coincidence gate		$z=(x \cdot y)=(x \wedge y)$	Output exists when both inputs exist
NOT gate, anticoincidence gate		$z=(x \cdot \sim y)$	Output exists when x but not y exists
Delay element		$z=x(t-\tau)$	Output equals input after delay τ
Trigger, flip-flop		$z=1$ if the last input was u or x when z was 0; $z=0$ if the last input was w or x when z was 1.	The trigger is "on" ($z=1$) if the output is at high potential. A brief delay (of the same order as the pulse width) is associated with the response
"Beginning" element		$z=1$ only when x rises positively	Output is a pulse, input is usually a step. Physical prototype is a capacitor-fed leaky diode

Appendix B

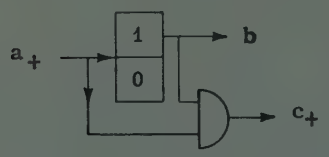
Binary Addition, Subtraction and Counting

Addition

The possibilities are exhausted by the truth table; the rule and the circuit follow.

Resident Digit b	Addend a_+	Resultant Digit b'	Carry c_+
0	0	0	0
1	0	1	0
0	1	1	0
1	1	0	1

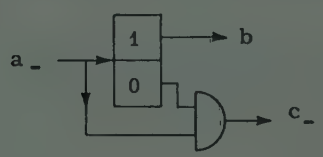
$$b' = (a_+ \not\equiv b), \quad c = (a_+ \cdot b)$$



Subtraction

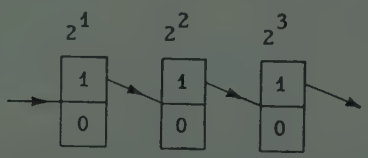
Resident Digit b	Subtrahend a_-	Resultant Digit b'	Carry c_-
0	0	0	0
1	0	1	0
0	1	1	1
1	1	0	0

$$b' = (a_- \not\equiv b), \quad c_- = (a_- \cdot \sim b)$$



Counters

Binary counting is performed by cascading flip-flops if these respond to signals of one polarity only, *e.g.*, negative going. (The input is also assumed to be negative going.)



With suitable gate connections, the circuit becomes a difference ("add-subtract" or "forward and backward going") counter, *i.e.*, it will add the X pulses and subtract the AS pulses. (A difference counter is shown in Fig. 9, together with gates G_4, G_5, G_6, and G_7 that prevent overflow.)

Appendix C

DRS For Computation

The digital nature of pulse rates and their self-decoding property commend their use in a variety of control systems. Precision, simplicity, speed and stability are enhanced on discarding the clock that has been held essential previously,[1] and on introducing rate difference detectors.

Methods for operating mathematically on the variable X/S represented by the pulse rate X will be considered briefly.

To add is to superimpose; a pulse antifouling circuit is devised readily to avoid loss by pulse coincidence. Subtraction is performed by means of a rate difference detector [Fig. 7(a), or Fig. 10 without the SSP and mixer]. Negative numbers are represented by a "minus" sign, *i.e.*, by the "negative" twin of the pulse-carrying line pair. Scale factors are provided by dividing circuits.

Multiplication of rates X and Y requires that one of them be staticized first, as in the measurement of the rate ratio X/S by the digitally represented no. A. Figure 12(a) shows the closed-loop arrangement; the two rate generators are similar, and their digit switches are ganged.

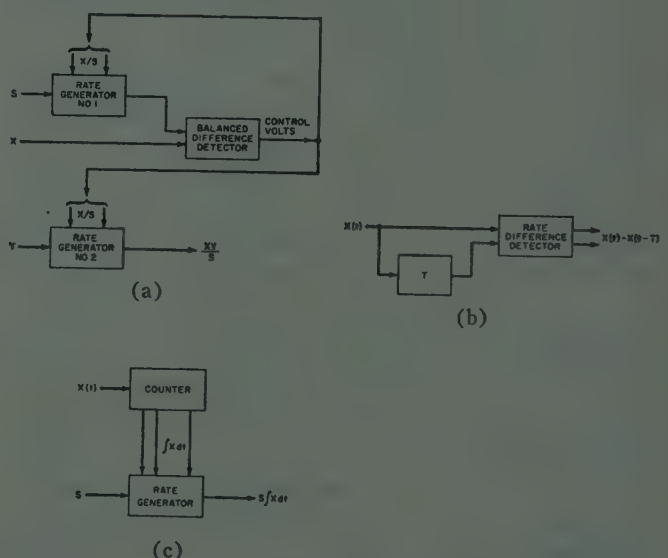


Fig. 12—Computing methods based on DRS: (a) multiplication, (b) differentiation, (c) integration.

Division is effected by the same scheme if the fixed rate S and the divisor rate Y are interchanged.

Differentiation is instrumented by a rate difference detector and a delay element [Fig. 12(b)].

Integration requires a counter (with overflow guard); the count controls a rate generator [Fig. 12(c)].

Correspondence

WWV Standard Frequency Transmissions*

Since October 9, 1957, the National Bureau of Standards radio stations WWV and WWVH have been maintained as constant as possible with respect to atomic frequency standards maintained and operated by the Boulder Laboratories, National Bureau of Standards. On October 9, 1957, the USA Frequency Standard was 1.4 parts in 10^9 high with respect to the frequency derived from the UT 2 second (provisional value) as determined by the U. S. Naval Observatory. The atomic frequency standards remain constant and are known to be constant to 1 part in 10^9 or better. The broadcast frequency can be further corrected with respect to the USA Frequency Standard, as indicated in the table; values are given as parts in 10^{10}. This correction is *not* with respect to the current value of frequency based on UT 2. A minus sign indicates that the broadcast frequency was low.

WWV Frequency†

1959		#1	#2	#3
September	1	−27	−30	−26
	2	−27	−30	−26
	3	−27	−29	−25
	4	−27	−29	−25
	5	−27	−30	
	6	−27	−30	
	7	−27	−29	
	8	−27	−29	−25
	9	−27	−29	−26
	10	−27	−29	−25
	11	−27	−29	−25
	12	−27	−29	
	13	−27	−29	
	14	−27	−30	−24
	15	−27	−29	−25
	16	−28	−28	−25
	17	−29	−29	−26
	18	−34	−34	−31
	19	−34	−33	
	20	−34		
	21	−34	−34	−31
	22	−33	−34	−31
	23	−31	−34	−31
	24	−30	−32	−27
	25	−30	−29	−25
	26	−28	−27	
	27	−27	−33	
	28	−26	−27	−24
	29	−25	−26	−23
	30	−24	−27	−23
October	1		−29	−26
	2		−24	−20
	3		−23	
	4		−19	
	5		−29	−24
	6		−19	−17
	7		−31	−27
	8		−32	−28
	9		−35	−31
	10		−39	
	11		−36	
	12		−35	−29
	13		−35	−30
	14		−35	−31
	15		−35	−30
	16		−35	−30

† WWVH frequency is synchronized with that of WWV.

Column #1 Vs NBS‡ atomic standards, Boulder, Colo., 30-day moving average seconds pulses at 15 mc.

Column #2 Vs atomichron at WWV, measuring time one hour at 2.5 mc.

Column #3 Vs atomichron at the U.S. Naval Naval Research Laboratory, Washington, D.C., measuring time 56 minutes at 2.5 mc.

‡ Method of averaging is such that an adjustment of frequency of the control oscillator appears on the day it is made. The following frequency adjustments were made:

September 17—minus 5×10^{-10}
October 2—minus 3×10^{-10}
October 4—minus 9×10^{-10}
October 6—minus 7×10^{-10}

The WWV and WWVH time signals are synchronized; however, they may gradually depart from UT 2 (mean solar time corrected for polar variation and annual fluctuation in the rotation of the earth). Corrections are determined and published by the U. S. Naval Observatory.

WWV and WWVH time signals are maintained in close agreement with UT 2 by making step adjustments in time of precisely plus or minus twenty milliseconds on Wednesdays at 1900 UT when necessary; a retarding time adjustment was made on September 30, 1959.

National Bureau of Standards
Boulder, Colo.

* Received by the IRE, October 28, 1959.

Low-Noise Parametric Amplifier Using Germanium *p-n* Junction Diode at 6 KMC*

In this correspondence, the authors report low-noise performance obtained for a parametric amplifier using a refrigerated germanium *p-n* junction diode for 6 kmc. The noise figure measured at 87°K for degenerate operation (double sideband) was 0.60 ± 0.05 db (excess noise temperature of 44°K). This is equivalent to a 3.6-db noise figure for ordinary single sideband operation. However, the sky temperature in this frequency range is so low that when the idler noise is radiated to a cold portion of the sky by use of an appropriate antenna, the noise contribution from the idler frequency is only slightly more than 44°K. The noise figure for the same amplifier measured at 296°K was 1.8 db (150°K) with 13 db of gain and a single sideband frequency bandwidth of 25 mc. For sake of comparison, it may be noted that at 3.1 kmc, Knechtli and Weglein[1] reported an excess noise temperature of 100°K (1.3-db double sideband noise figure) at room temperature, and 50°K at liquid nitrogen temperature for an amplifier utilizing a gold-bonded germanium diode. At higher frequencies, however, a higher noise figure is to be expected, since the minimum obtainable noise figure of a parametric amplifier is primarily determined by the Q of the diode,[2,3] $1/\omega CR_s$, where C is the average capacitance of the diode at the operating point, R_s is the spreading resistance of the diode, and ω is the angular frequency of the signal. As a matter of fact, at 6 kmc one of the authors measured a double sideband noise figure of 4.0 db at room temperature and 1.7 db at 80°K by utilizing the same gold-bonded diode. This result, while fairly good, is not as good as that already reported by the same author,[3] for a silicon *p-n* junction diode (1.4 db of double sideband noise figure at room temperature). The superior performance of the silicon *p-n* junction diode is due to its higher cutoff frequency. Recent advances in semiconductor diode technology have now made it possible to produce a high-quality *p-n* junction germanium diode which has extremely low noise temperature.

The new diode utilizes the diffused mesa-type *p-n* junction structure reported elsewhere,[4] and it is mounted in a modified version of a standard microwave diode cartridge. The zero bias capacitance is 0.79 $\mu\mu$f and the series resistance is 6.8 ohms. The dc resistance of the diode is higher than 50 megohms over the range from +0.15 volt to −2 volts. The reverse current is 20 μa at −4 volts, at which point the diode capacitance is 0.48 $\mu\mu$f.

The double sideband noise figures measured at various bias voltages are plotted in Fig. 1. Noise figures were measured with argon discharge lamp and they were double checked by reference to the noise from a matched load cooled to liquid nitrogen temperature. The gain of the amplifier was maintained constant at 13 db by adjusting the pump power, and the coupling between the waveguide and the cavity was adjusted for minimum noise output at each bias condition. The pump power, iris size, and the rectified current are also plotted in the same figure. The rectified current is negligibly small from zero bias to −1.4 volts, with no noise contribution expected in this range other than the thermal noise arising from the series resistance of the diode. The noise figures calculated theoretically agree very well with the measured values for reverse bias voltages less than 1.4 volts. For larger reverse bias voltages, the rectified current increases very rapidly as a result of the diode being driven into breakdown. A consequence of this is that the measured noise figures exceed the calculated values, the difference being attributed largely to contributions from shot noise as well as noise of the microplasm type.

To enable theoretical calculation of the noise figure, the pump voltage across the junction was graphically determined from the experimental results. The pump voltage for maintaining constant gain was found to be almost linearly proportional to the bias voltage, and the operating Q of the diode was calculated.

The optimum negative bias was around −1.1 volt for this particular diode, and so this was chosen as the bias voltage when the

* Received by the IRE, August 26, 1959.

[1] R. C. Knechtli and R. D. Weglein, "Low noise parametric amplifier," Proc. IRE, vol. 47, pp. 584–585; April, 1959.

[2] M. Uenohara, "Parametric Amplifier at 6 kmc Using Semiconductor Diodes." Reported at Sixteenth Annual Conference on Electron Tube Research, Quebec, Canada; June, 1958.

[3] M. Uenohara, "Noise consideration of the variable capacitance parametric amplifier," Proc. IRE, to be published.

[4] A. Uhlir, Jr., "The potential of semiconductor diodes in high-frequency communications," Proc. IRE, vol. 46, pp. 1099–1115; June, 1958.

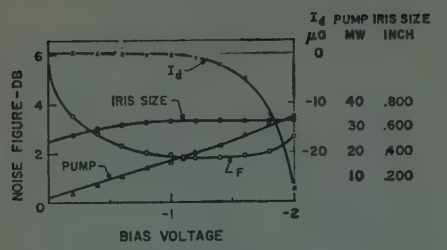


Fig. 1—Double sideband noise measured at various bias voltages. The gain of the amplifier is maintained constant at 13 db by adjusting pump power.

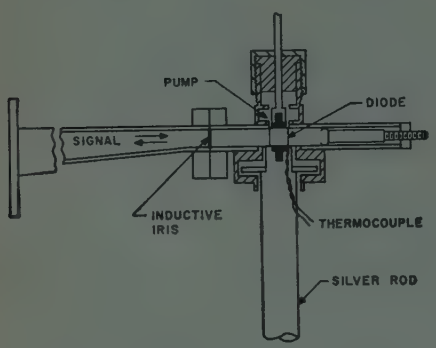


Fig. 2—Cross section of parametric amplifier with refrigeration arrangement.

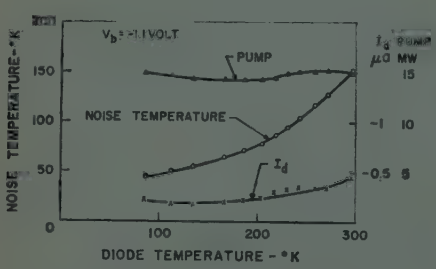


Fig. 3—The dependence of excess noise temperature upon diode temperature.

diode was refrigerated. The amplifier cavity used for the refrigeration experiment is shown in Fig. 2. The diode is refrigerated through the silver rod on which the diode is mounted. The temperature was measured at the top surface of the silver rod by an alumel-chromel thermocouple, so that the actual temperature of the junction may be slightly higher than that measured. However, the germanium crystal is soldered on the heavy metal block, which is mounted in the silver rod, while at the other end a very small area (about 1 mil²) of the crystal is in contact with a nickel pin. It is therefore expected that the temperature of the junction is very close to that measured. Dried nitrogen gas is circulated to avoid the condensation of moisture on the junction.

The experimental results are shown in Fig. 3. In this case, excess noise temperature is plotted instead of noise figure. The noise temperature decreased from 150°K to 44°K as the diode was refrigerated from 296°K to 87°K. Down to about 200°K, the fractional decrease of noise temperature exceeds that of the diode, but from 200°K down to the lowest temperature used, the fractional decrease of noise temperature is less than that of the diode. Similar characteristics have been observed for most of the germanium diodes (p-n junction and point contact), but the details of the characteristic differ from diode to diode depending on the amount of doping. The detailed characteristics of noise output of germanium, silicon, and gallium-arsenide diodes as a function of temperature will be reported later.

The authors wish to express their appreciation to Mrs. M. S. Boyle for her excellent work in connection with the diode fabrication.

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An Extremely Low-Noise 6-kmc Parametric Amplifier Using Gallium Arsenide Point-Contact Diodes*

In a recent paper[1] one of the authors reported that gallium arsenide (GaAs), one of the III–V intermetallic compounds, appeared to be an excellent semiconductor for use in high-frequency point-contact devices. The purpose of the present letter is to describe the extremely low noise performance obtained with a parametric amplifier using a refrigerated GaAs point-contact diode at 6 kmc. The noise figure measured at 90°K for double sideband operation was about 0.3 db (excess noise temperature of 21°K). We believe that about 10°K of the noise temperature was contributed from the circuit which had an operating temperature of about 270°K. The excess noise temperature evidently could be further reduced by complete refrigeration of the circuit. The noise figure of the amplifier operating as a degenerate single sideband device will be 3.3 db if the idler or image impedance is at room temperature. It is obvious, however, that the idler termination may also be refrigerated either by the use of liquid nitrogen or helium, or else the idler noise may be radiated directly to a cold portion of the sky by use of an appropriate antenna. If this is done, it is to be expected that the single sideband excess noise temperature of the GaAs amplifier will closely approach 42°K (twice the excess noise of the double sideband operation).

GaAs diodes used as parametric devices have several advantages over those made with either silicon or germanium. The high electron mobility, together with a higher energy gap and lower dielectric constant are favorable in obtaining the desired high Q over a large operating range of applied voltages. Further, the dissociation energy is low enough in GaAs so that the diodes may be operated at low temperatures. The GaAs diodes used in our parametric amplifier have the same physical dimensions as the microwave rectifiers described in the previous paper,[1] but are given special processing to prepare them for parametric applications. The cutoff frequency has been increased to 100 kmc or possibly higher by reducing the capacitance and resistance to a minimum. This has been accomplished by using heavily doped single crystal material having resitivities near 0.002 ohm cm. At the operating bias, the total capacitance of the point-contact and the diode case is reduced to approximately $\frac{1}{3}$ $\mu\mu$f. To minimize the noise, the GaAs surfaces are very highly polished and both the semiconductor surface and the sharp phosphor-bronze points are thoroughly cleaned immediately before assembly. The dc characteristics of this type of diode, after forming, are shown in Fig. 1.

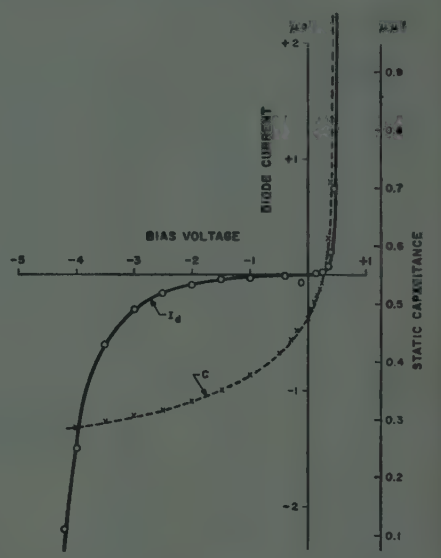

Fig. 1—Static characteristics of a GaAs point-contact diode.

The amplifier cavity used is exactly the same as that reported in a previous letter,[2] and the same technique is used to measure the noise figure. The accuracy of the measurements is believed to be ±3°K. The double sideband noise figures measured at 5.84 kmc while pumping at 11.7 kmc at various bias voltages are plotted in Fig. 2. These measurements were made at room temperature. To maintain consistent experimental conditions, the gain of the amplifier was maintained at 16 db by appropriately setting the pump power level. The single sideband bandwidth at this gain was about 25 mc. The minimum noise figure at room temperature was 0.9 db, with the diode biased 1.2 volts negatively. The noise at this bias is nearly pure thermal noise as the dc diode current is very nearly zero, precluding shot noise and noise due to internal microplasm.

The excess noise temperature of the amplifier was also measured as a function of the diode temperature. The results of this test are shown in Fig. 3. The excess noise

* Received by the IRE, September 1, 1959.

[1] W. M. Sharpless, "High frequency gallium arsenide point-contact rectifiers," *Bell Sys. Tech. J.*, vol. 38, pp. 259–269; January, 1959.

[2] M. Uenohara and A. E. Bakanowski, "Low noise parametric amplifier using germanium P-N junction diode at 6 kmc," Proc. IRE, this issue, p. 2113.

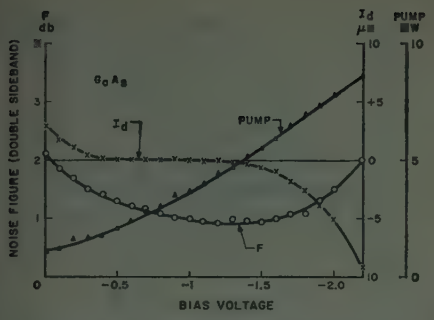

Fig. 2—Double sideband noise figure measured at various bias voltages. The gain of the amplifier is maintained constant at 16 db by adjusting pump power.

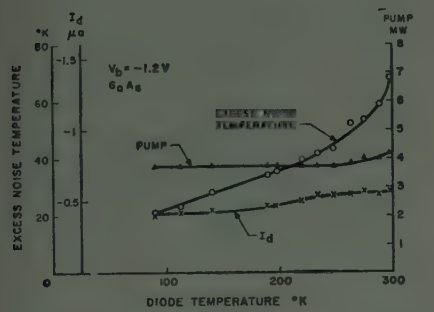

Fig. 3—The dependence of excess noise temperature upon diode temperature.

temperature decreased from 68°K at room temperature to 21°K at a diode temperature of 90°K. The pump power required for constant gain was almost constant over the entire temperature range. The excess noise temperature decreased almost linearly with the diode temperature from 220°K to 90°K. By extending the curve to the left, one can estimate that the noise contribution from the circuit is about 10°K. The justification for this construction stems from the presumption that the linear region of the characteristic implies a strict thermal representation of the diode noise source.

It is interesting to note that the excess noise temperature range obtained with the cooled GaAs parametric amplifier is of the order of that for a maser operating at this frequency. Because of its simplicity, such a parametric amplifier becomes a reasonable competitor of the maser from a systems point of view, considering the relatively large noise contribution from other portions of the system. It is possible that point-contact parametric amplifiers may be made to operate at frequencies well above the highest that have been reported to date.[2]

The authors wish to express their appreciation to T. W. Mohr for his valuable assistance in the measurements performed during the course of this study.

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[2] B. C. DeLoach and W. M. Sharpless, "An X band parametric amplifier," Proc. IRE, vol. 47, pp. 1664–1665; September, 1959.

X-Band Parametric Amplifier Noise Figures*

Noise figure measurements have been made on the X-band parametric amplifier previously reported.[1] The circuit has been slightly modified and two general types of gallium arsenide point-contact diodes have been examined. Typical capacity vs bias plots for these diodes are presented in Fig. 1.

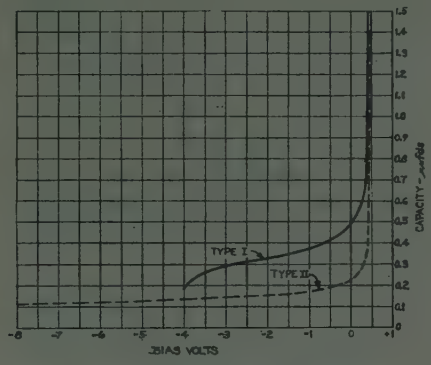

Fig. 1—Capacity vs. bias voltage for typical Type 1 and Type 2 diodes.

The continuous curve is representative of diodes made with 0.002–0.003 ohm-cm material and the dashed curve is representative of diodes made with 0.02–0.03 ohm-cm material. These two general types will be referred to as Types 1 and 2, respectively.

Table I presents data obtained for room temperature operation of these diodes. Degenerate amplification was employed with a center frequency of 11.55 kmc with a K-band pump frequency of 23.10 kmc.

TABLE I

Type	Gain (db)	Bandwidth (mc)	Double Sideband Noise Figure
1	10	53	3.2
1	15	26	3.3
1	15	20	3.7
1	10	20	3.8
1	10	38	3.8
2	10	80	4.0
2	10	50	4.5

The X-band circulator employed in conjunction with these measurements had an input path transmission loss of 0.18 db, the effect of which was not included in the noise figures presented.

The diodes of Type 2 were slightly worse in noise figure performance. There does, however, seem to be an advantage in gain bandwidth product associated with this general type. Several of these diodes (not included in the noise figure table above) have produced bandwidths on the order of 80 mc and 10-db gain. However, the 53-mc figure with 10-db gain included in Table I for a Type 1 diode represents the best gain bandwidth product obtained to date for a diode of this type. This greater gain-bandwidth product has tentatively been ascribed to a better circuit match to the lower average capacity of Type 2 diodes and suggests that circuit refinements may lead to better noise figures and gain-bandwidth products for both types of diodes.

Significant improvement in noise figure performance is to be expected as the operating temperature of the diodes is reduced, as has been demonstrated for similar diodes at 6 kmc.[2]

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* Received by the IRE, September 24, 1959.

[1] B. C. De Loach and W. M. Sharpless, "An X-band parametric amplifier," Proc. IRE, vol. 47, pp. 1664–1665; September, 1959.

[2] M. Uenohara and W. M. Sharpless, "An Extremely low noise 6-kmc. parametric amplifier using gallium arsenide point-contact diodes," this issue, p. 2114.

General Energy Relations in Nonlinear Reactances*

The purpose of this paper is to discuss in some detail an alternate derivation for the general energy relations for nonlinear reactors.[1] This alternate method does not appear to be simpler or more straightforward than the original analysis.[1] This paper has been prompted by several similar derivations which have recently appeared.[2–4]

To first summarize several equations from Manley and Rowe,[1] consider a nonlinear capacitor with a single-valued characteristic defined by

$$v = f(q). \tag{1}$$

The charge q and voltage v may be written as double Fourier series:

$$q = \sum_{m=-\infty}^{\infty} \sum_{n=-\infty}^{\infty} Q_{m,n} e^{j(mx+ny)} \tag{2}$$

$$v = \sum_{m=-\infty}^{\infty} \sum_{n=-\infty}^{\infty} V_{m,n} e^{j(mx+ny)} \tag{3}$$

$$x = \omega_1 t \qquad \omega_1 = 2\pi f_1$$

$$y = \omega_0 t \qquad \omega_0 = 2\pi f_0. \tag{4}$$

The current i is similarly

$$i = \frac{dq}{dt} = \sum_{m=-\infty}^{\infty} \sum_{n=-\infty}^{\infty} I_{m,n} e^{j(mx+ny)}, \tag{5}$$

where

$$I_{m,n} = j(m\omega_1 + n\omega_0) Q_{m,n}. \tag{6}$$

The average power flowing into the nonlinear capacitor at the frequencies $\pm|mf_1+nf_0|$ is

* Received by the IRE, April 29, 1959.

[1] J. M. Manley and H. E. Rowe, "Some general properties of non-linear elements—Part I. general energy relations," Proc. IRE, vol. 44, pp. 904–913; July, 1956.

[2] C. H. Page, "Frequency conversion with nonlinear reactance," *J. Res. NBS*, vol. 58, pp. 227–236; May, 1957.

[3] B. Salzberg, "Masers and reactance amplifiers—basic power relations," Proc. IRE, vol. 45, pp. 1544–1545; November, 1957.

[4] P. A. Clavier, "On the Manley-Rowe relations," Proc. IRE, vol. 47, pp. 1781–1782; October, 1959.

$$W_{m,n} = 2 \operatorname{Re} V_{m,n} I^*_{m,n}$$
$$= -(mf_1 + nf_0) 4\pi \operatorname{Re} jV_{m,n} Q^*_{m,n}. \quad (7)$$

Now since the nonlinear capacitor is assumed lossless, we have from conservation of energy

$$\sum_m \sum_n W_{m,n} = 0, \quad (8)$$

where the region of the summations is taken to include the power corresponding to each frequency only once. Eq. (8) may be rewritten, following Page,[2] by dividing and multiplying each term by its corresponding frequency.

$$\sum_m \sum_n \frac{W_{m,n}}{mf_1 + nf_0} (mf_1 + nf_0) = 0. \quad (9)$$

Splitting into two terms, and writing the appropriate ranges for the summations, we have

$$f_1 \sum_{m=0}^{\infty} \sum_{n=-\infty}^{\infty} \frac{mW_{m,n}}{mf_1 + nf_0} + f_0 \sum_{m=-\infty}^{\infty} \sum_{n=0}^{\infty} \frac{nW_{m,n}}{mf_1 + nf_0} = 0. \quad (10)$$

We observe that if each of the two terms of (10) may be separately set equal to zero, we will have the general energy relations of Manley and Rowe.[1] This has been shown in the three-frequency case by Salzberg.[3] We present here a somewhat different discussion which is suitable for the general case.

Consider an ensemble of systems with identical nonlinear elements and identical $Q_{m,n}$'s and $V_{m,n}$'s, but having all possible different fundamental frequencies f_1 and f_0. The external impedances and generators will have to be changed as f_0 and f_1 change in order to accomplish this. Then from (7) the quantities $W_{m,n}(mf_1+nf_0)$ appearing in the summations of (10) are independent of the fundamental frequencies f_1 and f_0. Since (10) must hold for each member of the ensemble, *i.e.*, for all values of f_1 and f_0, each of the two terms of (10) must be separately equal to zero, thus yielding the general energy relations of Manley and Rowe.[1]

The original analysis[1] established that each of the summations in (10) is identically equal to zero by direct calculation. The present analysis obtains these results by examining their functional dependence. In either case the general energy relations are obtained not from conservation of energy alone, but depend also on the properties of the particular device. These are: 1) it is a capacitor with a nonlinear charge-voltage characteristic, thus causing new frequencies to arise whose charge and voltage components are determined by this characteristic; 2) since it is a capacitor, expressions for real power in terms of these charge and voltage components must contain the frequency factors shown in (7).

The present discussion of course applies equally well to nonlinear inductors.

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Monotonicity and Maximally Flat Rational Functions*

For many applications of equipment with filter-like properties it is required that the pass band exhibit no peaks or ripples; that is, the system transmission must decrease smoothly up to the cutoff frequency. If the system transmission function is described by the reciprocal of a polynomial, it is well known that the so-called maximally flat function[1] (among others[2]) will accomplish this objective. On the other hand, if the transmission function must be described by a more general rational function,[1,3] the matter is not so obvious. It will be shown that for a number of common cases in loss-free filter design, where the transmission zeros are found either on the real or on the imaginary axis, or in mixed combinations, the maximally flat design still provides a function with a transmission which diminishes smoothly (monotonically) up to the first zero on the s-plane ω axis, for $\omega > 0$.

It will be remembered that a maximally flat design results when as many successive derivatives as possible are equated to zero, at $\omega = 0$. In other terms, as many successive coefficients as possible (in ascending powers of ω^2) of the numerator and denominator of the transmission function should be equated.[1] As a particular example, if the degree of the denominator polynomial (in ω^2) exceeds that of the numerator polynomial by one, the (maximally flat) squared-magnitude transmission function may be expressed as

$$|t|^2 = \frac{N(\omega^2)}{D(\omega^2)} = \frac{N(\omega^2)}{N(\omega^2) + b_K \omega^{2(2K+1)}}, \quad (1)$$

where

$$N(\omega^2) = \prod_{k=1}^{K} \left[1 + (2 \cos 2\theta_k) \left(\frac{\omega}{\omega_k}\right)^2 + \left(\frac{\omega}{\omega_k}\right)^4 \right]. \quad (2)$$

The parameter ω_k is the magnitude of each of the four transmission zeros associated with each kth factor of (2), and θ_k is the angular displacement of these transmission zeros from the real axis in the complex frequency plane, $s = \sigma + j\omega$, as shown in Fig. 1. If the function $|t|^2$ is monotone with respect to ω, it will be also with respect to ω^2. Therefore, differentiating with respect to ω^2 gives

$$\frac{d|t|^2}{d\omega^2} = -\frac{\omega^{4K} b_K}{D^2} [(2K+1)N - \omega^2 N'], \quad (3)$$

where

$$N' = \frac{dN}{d\omega^2} = \frac{2N}{\omega^2} \sum_{k=1}^{K} \left[\frac{\cos 2\theta_k \left(\frac{\omega}{\omega_k}\right)^2 + \left(\frac{\omega}{\omega_k}\right)^4}{1 + 2\cos 2\theta_k \left(\frac{\omega}{\omega_k}\right)^2 + \left(\frac{\omega}{\omega_k}\right)^4} \right]. \quad (4)$$

* Received by the IRE, June 15, 1959.

[1] W. A. Lynch, "The role played by derivative adjustment in broadband amplifier design," *Proc. Symp. on Modern Network Synthesis*, Polytechnic Institute, Brooklyn, N. Y., pp. 193–201; April, 1952.

[2] A. Papoulis, "Optimum filters with monotonic response," Proc. IRE, vol. 36, pp. 606–609; March, 1958.

[3] J. L. Stewart, "Flatness and symmetric low-pass lossless filters," IRE Trans. on Circuit Theory, vol. CT-5, pp. 128–132; June, 1958.

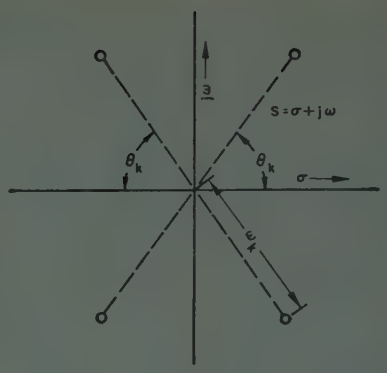

Fig. 1.

Substituting (4) into (3) gives

$$\frac{d|t|^2}{d\omega^2} = \frac{-b_K N \omega^{4K}}{D^2} \left[2K + 1 - 2 \sum_{k=1}^{K} F_k \right] \quad (5)$$

where

$$F_k = \frac{\cos 2\theta_k \left(\frac{\omega}{\omega_k}\right)^2 + \left(\frac{\omega}{\omega_k}\right)^4}{1 + 2\cos 2\theta_k \left(\frac{\omega}{\omega_k}\right)^2 + \left(\frac{\omega}{\omega_k}\right)^4} \leq 1 \quad (6)$$

if

$$\theta_k \leq 45° \text{ (for all } k) \quad (7a)$$

or

$$\omega < \frac{\omega_k}{\sqrt{-\cos 2\theta_k}} \text{ (for all } k \text{ where } \theta_k > 45°). \quad (7b)$$

Consequently, one obtains

$$2 \sum_{k=1}^{K} F_k \leq 2K, \quad (8)$$

and, as b_K, N, D^2 and ω^{4K} in (5) are all positive it follows that,

$$\frac{d|t|^2}{d\omega^2} < 0 \quad (9)$$

for all ω satisfying (7b), and perhaps beyond. If (7a) holds, note that the transmission function is monotone decreasing for all (real) ω greater than zero. As a special case, if all of the zeros are located on either the real or the imaginary axis or in combinations thereof, then $\theta_k = 0°$ or 90° and the restriction of (7b) becomes

$$\omega \leq \omega_k \text{ (for all } k). \quad (10)$$

Thus, the transmission function is monotone decreasing up to the first zero on the ω (or imaginary) axis in the s plane and *not beyond*.

Consider an "almost maximally flat," squared-magnitude transmission function of the form

$$|t|^2 = \frac{N(\omega^2) + a_K \omega^{2(2K+1)}}{N(\omega^2) + b_K \omega^{2(2K+1)}} = \frac{\overline{N}(\omega^2)}{\overline{D}(\omega^2)} \quad (11)$$

where it is assumed that a_K and b_K may not be equated for physical reasons. Differentiating with respect to ω^2 gives

$$\frac{d|t|^2}{d\omega^2} = -\frac{(b_K - a_K)\omega^{4K}}{\overline{D}^2(\omega)} \cdot [(2K+1)N - \omega^2 N'] \quad (12)$$

As there can be no power gain at infinity with passive networks ($|t|^2 \leq 1$),

$$b_K - a_K \geq 0 \quad (13)$$

and the same arguments which followed (3) will also hold in this case.

Next, consider a form for $|t|^2$:

$$|t|^2 = \frac{N(\omega^2)}{N(\omega^2) + R(\omega^2)} = \frac{N(\omega^2)}{\bar{D}(\omega^2)} \quad (14)$$

where $N(\omega^2)$ is as defined in (2) and $R(\omega^2)$ represents additional denominator terms (not equatable to the numerator):

$$R(\omega^2) = \sum_{j=K}^{K+M} b_j \omega^{2(2j+1)}. \quad (15)$$

Thus,

$$\frac{d|t|^2}{d\omega^2} = \left[-b_K \frac{\omega^{4K}}{\bar{D}^2} [(2K+1)N - N'\omega^2] - b_{K+2} \frac{\omega^{4K+2}}{\bar{D}^2} [(2K+2)N - N'\omega^2] \right.$$
$$\cdots\cdots\cdots\cdots\cdots \quad (16)$$
$$\left. - b_{K+M} \frac{\omega^{4K-M}}{\bar{D}^2} [(2K+M)N - N'\omega^2] \right] < 0$$

(if b_K through b_{K+M} are all positive and equations (7) are satisfied) and again the function is monotone decreasing.

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Parametric Amplification and Conversion in Propagating Circuits Using Nonlinear Reactances*

Tien has presented an analysis of parametric amplification and conversion in propagating circuits by using a time-varying reactance as the coupling element between two propagating circuits.[1] The purpose of this note is to show that similar results can be obtained by using a nonlinear reactance to couple three propagating curcuits. To the writer's knowledge, this approach has been used in studying resonant-circuit parametric devices but not for propagating circuit models. This method can lead to the large-signal theory.

The transmission line equation, neglecting the series resistance of the wires and the shunt conductance, can be written in the following form:

$$\partial V(z,t)/\partial z = -\partial\phi(z,t)/\partial t$$
$$\partial I(z,t)/\partial z = -\partial q(z,t)/\partial t \quad (1)$$

where t is time, z is distance, $V(z,t)$ is the potential along the line, $I(z,t)$ is the current, $\phi(z,t)$ is flux linkage per unit length, and $q(z,t)$ is the charge per unit length.

In the model shown in Fig. 1 only nonlinear inductive coupling is used. $\partial q/\partial t$ becomes the ordinary $C\partial V/\partial t$ and $\partial\phi/\partial t$ will contain coupling terms in addition to the ordinary $L\partial i/\partial t$.

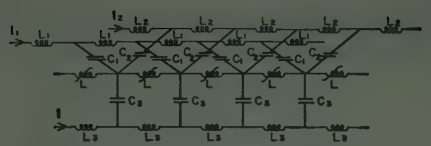

Fig. 1—An equivalent circuit of a traveling-wave parametric circuit.

In the nonlinear inductance, the voltage and flux relation is

$$V = -\partial\phi/\partial t = -(\partial\phi/\partial i)(\partial i/\partial t) = -L(i)\partial i/\partial t \quad (2)$$

and

$$\partial\phi/\partial t = L_0(\partial\mathcal{I}/\partial t) + L_0'\mathcal{I}(\partial\mathcal{I}/\partial t) + \tfrac{1}{2}L_0''\mathcal{I}^2(\partial\mathcal{I}/\partial t) + \cdots \quad (3)$$

where L_0, L_0', $L_0'' \cdots$ are the values of L and its derivatives (with respect to current) evaluated at I_0; the dc part of the current $i(z,t)$, $\mathcal{I}(z,t)$ is the ac part of $i(z,t)$.

Referring to Fig. 1,

$$\mathcal{I}(z,t) = I_1(z)\cos(\omega_1 t - \beta_1' z + \theta_1) + I_2(z)\cos(\omega_2 t - \beta_2' z + \theta_2) + I(z)\cos(\omega t - \beta z + \theta). \quad (4)$$

Substituting (4) in (3), we can obtain the components of $\partial\phi/\partial t$ at ω_1, ω_2 and ω.

$$(\partial\phi/\partial t)_1 = -\omega_1\left[L_0 + \frac{1}{2}L_0''\frac{I_1^2 + 2I_2^2 + 2I^2}{4}\right] \cdot I_1 \sin(\omega_1 t - \beta_1' z + \theta_1) - \tfrac{1}{2}\omega_1 L_0' I_2 I \sin(\omega_1 t - \beta_1' + \theta \mp \theta_2). \quad (5)$$

Similar equations can be written for $(\partial\phi/\partial t)_2$ and $(\partial\phi/\partial t)$. Here the upper sign is for case a) where $\omega = \omega_1 + \omega_2$, and the lower sign is for case b) where $\omega = \omega_1 - \omega_2$. θ_1, θ_2, and θ are initial phases. Most of the notations employed here follow those used by Tien.[1]

Neglecting the current-dependent inductance term in the first term at the right-hand side of (5) as being small compared to L_0, we can write the transmission line equation for the ω_1-circuit as

$$\partial V_1/\partial z = \omega_1(L_{11} + L_0)I_1 \sin(\omega_1 t - \beta_1' z + \theta_1) + \tfrac{1}{2}\omega_1 L_0' I_2 I \sin(\omega_1 t - \beta_1' z + \theta \mp \theta_2)$$
$$\partial I_1/\partial z = -C_1\partial V_1/\partial t, \quad (6)$$

and similar equations for the ω_2 and ω circuits. L_{11} is the inductance per unit length of ω_1 circuit.

Combining the pair of equations of (6) and similar pairs for the ω_2 and ω circuits, we finally obtain

$$\frac{\partial I_1}{\partial z} - jk_1\Delta\beta I_1 = -j\frac{1}{4}\frac{\omega_1 B_1 L_0'}{\beta_1'} I I_2 e^{j(\theta \mp \theta_2 - \theta_1)},$$
$$\frac{\partial I_2}{\partial z} - jk_2\Delta\beta I_2 = -j\frac{1}{4}\frac{\omega_2 B_2 L_0'}{\beta_2'} I_1 I e^{j(\pm\theta \mp \theta_1 - \theta_2)},$$
$$\frac{\partial I}{\partial z} = -j\frac{1}{4}\frac{\omega B L_0'}{\beta} I_1 I_2 e^{j(\pm\theta_2 + \theta_1 - \theta)}. \quad (7)$$

Notice the similarity and difference between these equations and those of Tien. For small signal theory, the second term on the right-hand side of the expression $\partial V/\partial z$, similar to that in (6), is neglected. Then $I(z)$ becomes a constant and (7) becomes identical to that in Tien's work, if a substitution $I_1'(z) = I_1(z)e^{j\theta_1}$, $I_2'(z) = I_2(z)e^{j\theta_2}$ and $I'(z) = I(z)e^{j\theta}$ is used. The expression for ξ given by Tien becomes

$$\xi^2 = \frac{\omega_1\omega_2 B_1 B_2 L_0'^2 |I|^2}{4\beta_1'\beta_2'}. \quad (8)$$

The exact solution of (7) without the small-signal assumption is difficult to obtain. However, if $\Delta\beta = 0$, some useful results can be obtained. Using (7) and its complex conjugates, one can have for case a),

$$-|I_1|^2 Z_{01}/\omega_1 = -|I_2|^2 Z_{02}/\omega_2 = |I|^2 Z_0/\omega; \quad (9)$$

and for case b)

$$|I_1|^2 Z_{01}/\omega_1 = -|I_2|^2 Z_{02}/\omega_2 = -|I|^2 Z_0/\omega. \quad (10)$$

The above relations are simply Manley and Rowe's power relation. From (7) one can also obtain the first-order large-signal solution from the following:

$$\frac{d^2 I_1}{dz^2} = \pm\left[\frac{1}{16}\frac{\omega_1\omega_2 B_1 B_2 L_0'^2 |I|^2}{\beta_1\beta_2} \mp \frac{\omega B\beta_1}{\omega_1 B_1\beta}\left|\frac{1}{I}\frac{dI_1}{dz}\right|^2\right] I_1. \quad (11)$$

The second term in the brackets shows the saturation effect.

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Noise Figure for a Traveling-Wave Parametric Amplifier of the Coupled-Mode Type*

The theoretical noise figure for a traveling wave parametric amplifier of the continuously-coupled transmission line type has been calculated. This theory is applicable to the traveling-wave parametric amplifier employing discrete diodes insofar as the particular structure can be treated as a distributed network.

The calculation employs the normal coupled-mode equations for weak coupling and introduces distributed thermal noise sources, $n_s(z)$ and $n_i(z)$, at signal and idler frequencies, respectively. Noise sources at different positions of the structure are considered to be uncorrelated, hence $\overline{n_i^*(z_1)n_i(z_2)} = \overline{n_i^2}\delta(z_1 - z_2)$ and $\overline{n_s^*(z_1)n_s(z_2)} = \overline{n_s^2}\delta(z_1 - z_2)$. The mean square values, $\overline{n_s^2}$ and $\overline{n_i^2}$, are related to the attenuation constant (nepers-per-unit length) for idler, α_i, and for signal α_s, by

$$\overline{n_i^2} = 2\alpha_i kT\Delta f \qquad \overline{n_s^2} = 2\alpha_s kT\Delta f. \quad (1)$$

* Received by the IRE, June 8, 1959.

[1] P. K. Tien, "Parametric amplification and frequency mixing in propagating circuits," *J. Appl. Phys.*, vol. 29, pp. 1347–1357, September, 1958.

* Received by the IRE, June 8, 1959.

where

k = Boltzmann constant,
T = ambient temperature of the device,
Δf = bandwidth of the device.

The relationships in (1) are obtained by considering an element dz of the device which is at a temperature T and at thermal equilibrium. A power $kT\Delta f$ enters the element and is attenuated, and noise power is added from the thermal noise $\overline{n^2}$; hence the output is $(1-2\alpha dz)kT_0\Delta f+\overline{n^2}dz$. This total output power must equal $kT\Delta f$, since the system is at a constant temperature T and thermal equilibrium. Consideration of this equality leads to the relationships expressed in (1).

For the case of no coupling between the idler and signal modes, the z and time dependencies for the idler and signal modes, respectively, are given by $\exp(-\gamma_i z+j\omega_i t)$ and $\exp(-\gamma_s z+j\omega_s t)$, where $\gamma_s=\alpha_i+j\beta_i$ and $\gamma_s=\alpha_s+j\beta_s$ are the propagation constants. It is presumed that the coupling coefficients, C_{si} and C_{is}, between the signal and idler modes have a dependency of $\exp(-j\beta_p z+j\omega_p t)$, where subscript p refers to pump signal and no loss is assumed. The angular frequencies are related by $\omega_i=\omega_p-\omega_s$.

Consider the case of weak coupling between the signal and idler frequencies. These signals may be propagating in the same mode or in different modes of the structure. Represent the amplitudes of the forward wave of the idler and signal frequencies by a_i and a_s, respectively. The amplitudes are so normalized that $a_i a_i^*$ and $a_s a_s^*$ are the powers carried by the waves.

In absence of coupling, the wave amplitudes satisfy

$$\frac{da_s}{dz}=-\gamma_s a_s, \qquad \frac{da_i}{dz}=-\gamma_i a_i, \tag{2}$$

where γ_s and γ_i are the propagation constants of the unperturbed waveguide for the signal and idler frequencies, respectively.

If the coupling is introduced between the waves, the presence of one wave affects the rate of change of the amplitude of the other. For weak coupling, it presumed that γ_i and γ_s are unaffected and that the coupling is properly taken into account by setting

$$\begin{aligned}\frac{da_s}{dz}&=-\gamma_s a_s+C_{si}a_i^*+n_s,\\ \frac{da_i^*}{dz}&=C_{is}a_s-\gamma_i^* a_i^*+n_i.\end{aligned} \tag{3}$$

The distributed thermal noise sources have been included in the equations. (Compare (4.3) of Haus.[1]) Here, we interpret the lower sideband frequency, $\omega_i=\omega_p-\omega_s$, as positive as opposed to the convention of Haus.[1] This necessitates complex conjugate signs on all amplitudes pertaining to $\omega_i(>0)$. As $\omega_i+\omega_s=\omega_p$, the time dependencies cancel in the above equations.

Consideration of the power relationship given by Manley and Rowe[2] [1] yields the relationship between the amplitude coupling coefficients

$$\frac{C_{si}}{\omega_s}=\frac{C_{is}^*}{\omega_i}. \tag{4}$$

The solution for a_s in terms of the noise sources, n_i and n_s, is achieved by the method of undetermined coefficients (see Hildebrand[3]). The solution is

$$\begin{aligned}a_s=&-k_a e^{-j\beta_1 z}\int_0^z e^{j\beta_1 z_1}n_s(z_1)dz_1\\&+k_b e^{-j\beta_1 z}\int_0^z C_{si}e^{j\beta_1 z_1}n_i(z_1)dz_1\\&+k_c e^{-j\beta_2 z}\int_0^z e^{j\beta_2 z_1}n_s(z_1)dz_1\\&-k_b e^{-j\beta_2 z}\int_0^z C_{si}e^{j\beta_2 z_1}n_i(z_1)dz_1,\end{aligned} \tag{5}$$

where

$$\begin{aligned}\beta_{1,2}&=-j\frac{\gamma_s+\gamma_i^*+\gamma_p}{2}\\&\pm\sqrt{-\frac{(\gamma_s-\gamma_i^*-\gamma_p)^2}{4}-\frac{\omega_i}{\omega_s}|C_{si}|^2}\end{aligned} \tag{6}$$

$$k_a=\frac{\beta_2-j\gamma_s}{\beta_1-\beta_2}\quad k_b=\frac{j}{\beta_1-\beta_2}\quad k_c=\frac{\beta_1-j\gamma_s}{\beta_1-\beta_2}.$$

If the real part of the quantity under the square-root sign is negative, β_1 is a growing wave and β_2 is an attenuating wave.

For a lossless structure, this condition is given by

$$\frac{(\beta_s+\beta_1-\beta_p)^2}{4}-\frac{\omega_i}{\omega_s}|C_{si}|^2<0.$$

For a given coupling $|C_{si}|^2$, this gain term is maximized by requiring

$$\beta_s=\beta_i-\beta_p=0. \tag{7}$$

Eq. (7) is the synchronism condition derived by Tien.[4]

The exact solution for a short-length or moderate-gain device involves both of these waves, β_1 and β_2. This complete solution is omitted here and consideration is given to the high-gain solution. Hence, a_s may be represented by the first two terms of (5), which are the growing wave terms. The power at the signal frequency at the position z caused by the noise generators n_i and n_s is given by

$$\begin{aligned}P_s(z)=a_s a_s^*=&|k_a|^2 e^{-j\beta_1 z}e^{+j\beta_1^* z}\\&\cdot\int_0^z\int_0^z e^{j\beta_1 z_1}e^{-j\beta_1^* z_2}\overline{n_s^*(z_2)n_i(z_1)}dz_2dz_1\\&+|k_b|^2 e^{-j\beta_1 z}e^{+j\beta_1^* z}\\&\cdot\int_0^z\int_0^z C_{si}C_{si}^* e^{j\beta_1 z_1}e^{-j\beta_1 z_2}\overline{n_s^*(z_2)n_i(z_1)}dz_2dz_1.\end{aligned} \tag{8}$$

The excess noise figure is given by

$$F-1=\frac{N_{ns}+N_{ni}+N_i}{N_s}, \tag{9}$$

where

N_{n_s} = output noise power at the signal frequency due to the distributed thermal noise source, $n_s(z)$,
N_{ns} = output noise power at the signal frequency due to distributed thermal noise source, $n_s(z)$,
N_i = output noise power at the signal frequency due to thermal noise power at idler input terminals T_i = idler input temperature,
N_s = outout noise power at the signal frequency due to the thermal noise at signal input terminals, which is taken to be at room temperature for reference, T_0.

The terms N_i and N_s are evaluated from (8) by having $\overline{n_i^*(z_2)n_i(z_1)}=kT_i\Delta f\ \delta(z_2)\delta(z_1)$ and $\overline{n_s^*(z_2)n_s(z_1)}=kT_0\Delta f\ \delta(z_2)\delta(z_1)$. The N_{n_i} and N_{n_s} terms are evaluated from (8) by considering that the thermal noise generators at different positions along the structure are uncorrelated; hence $\overline{n_i^*(z_2)n_i(z_1)}=\overline{n_i^2}\delta(z_1-z_2)$ and $\overline{n_s^*(z_2)n_s(z_1)}=\overline{n_s^2}\delta(z_1-z_2)$, where $\overline{n_i^2}$ and $\overline{n_s^2}$ are related to the attenuation (nepers per unit length) for idler and signal by (1), where T is taken as the ambient temperature T_0.

Putting these results in (9) and ignoring the constant terms in comparison with the exponentially increasing terms, one obtains

$$F-1=\frac{\alpha_s}{\alpha_1}+\frac{|k_b|^2}{|k_a|^2}|C_{si}|^2\left[\frac{\alpha_i}{\alpha_1}+\frac{T_i}{T_0}\right], \tag{10}$$

where

α_s = loss (nepers per unit length) for the signal frequency,
α_i = loss (nepers per unit length) for the idler frequency,
α_1 = gain (nepers per unit length) for the signal frequency when the structure is active; *i.e.*, being pumped. This is the imaginary part of the growing wave propagation constant, β_1.

If the device is cooled to a temperature, T_s, then a T_s/T_0 term should appear in the nontemperature terms in (10).

For a lossless sytem, $\alpha_i=\alpha_s=0$, (10) becomes

$$F-1=\frac{\omega_s}{\omega_i}\frac{T_i}{T_0}. \tag{11}$$

Use has been made of (6) to evaluate k_a and k_b for the lossless case in order to derive (11) from (10). Eq. (11) is the result reported by Tien.[4]

If the structure is matched to the antenna at the input of idler and signal, then the noise of the second stage will be radiated out of the input and may be ignored. This connection would also put $T_i=T_a$, the antenna temperature, and, hence, a lower noise figure would be achieved if the antenna were pointed into free space.

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[1] H. A. Haus, "The kinetic power theorem for parametric, longitudinal, electron-beam amplifiers," IRE Trans. on Electron Devices," vol. ED-5, pp. 225–232; October, 1958.
[2] *Ibid.*, footnote 3, page 226.
[3] F. B. Hildebrand, "Advanced Calculus for Engineers," Prentice-Hall, Inc., New York, N. Y., pp. 27–31; 1949.
[4] P. K. Tien, "Parametric amplification and frequency mixing in propagating circuits," *J. Appl. Phys.*, vol. 29, pp. 1347–1357; September, 1958.

Antenna Power Densities in the Fresnel Region*

Introduction

The large average powers used in some current radar and communications systems have raised the problem of personnel safety, particularly irreversible eye damage. This letter presents calculations and curves of maximum power density as a function of distance from the antenna for several typical aperture distributions.

Two factors are of interest: 1) maximum power density envelope, and 2) gain reduction, which is also approximately the beamwidth broadening factor. The apertures considered are: a) square with uniform illumination, b) circular with uniform illumination, and c) circular with $(1-\rho^2)$ taper. Let R be the distance to the aperture.

Square Aperture with Uniform Illumination

The on-axis power (field squared) is given by[1]

$$P = 16.4\left[C^2(1/2\sqrt{x}) + S^2(1/2\sqrt{x})\right]^2 \quad (1)$$

where C and S are Fresnel integrals and

$$x = \frac{R}{2L^2/\lambda}$$

is the distance as an inverse fraction of the distance $2L^2/\lambda$. The choice of coefficient normalizes the power density to unity at $R=2L^2/\lambda$ for a square of side L.

Fig. 1 shows that the greatest power density is 12.7 times the density at $2L^2/\lambda$. As the observation distance moves in closer to the antenna, the main beam alternately divides and reforms to produce an oscillating curve. The dashed line is the envelope of maximum power density vs distance. Close to the antenna, the density oscillates about a value of four.

Because the antenna gain and beamwidth are both degraded in the Fresnel region, a gain reduction factor is obtained by comparison of the (on-axis) intensity about a spherical surface for the focused aperture with that of the unfocused aperture. The gain is reduced by $1/\gamma$,[2] where

$$\gamma = \frac{y}{4\left[C^2(\sqrt{y}/2) + S^2(\sqrt{y}/2)\right]}$$

and

$$y = \frac{2L^2/\lambda}{R}. \quad (2)$$

The beamwidth is broadened approximately by γ, which is plotted in Fig. 2. For large apertures the asymptotic value is $\gamma=(1/2)y$. In addition γ is also called a defocusing factor.

Circular Aperture with Uniform Illumination

For an aperture of diameter D the Fresnel field squared is given by[2]

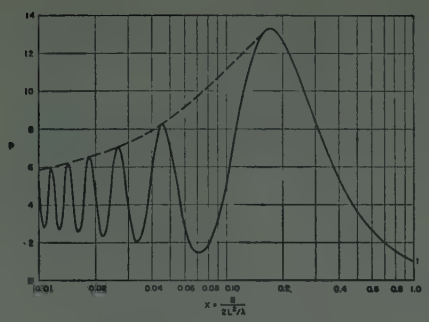

Fig. 1—On-axis power density, uniform square aperture.

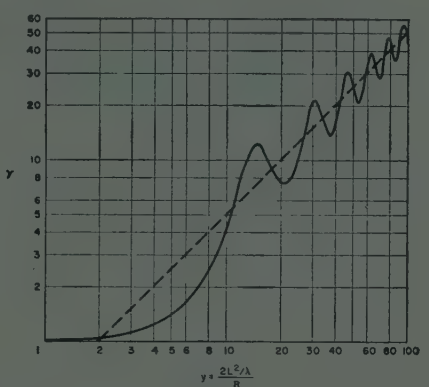

Fig. 2—Defocusing factor, uniform square aperture.

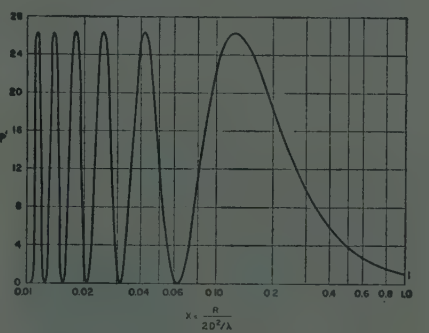

Fig. 3—On-axis power density, uniform circular aperture.

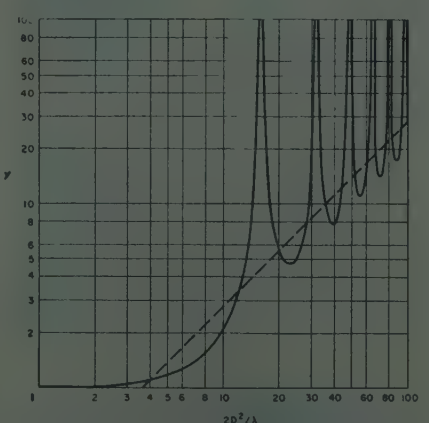

Fig. 4—Defocusing factor, uniform circular aperture.

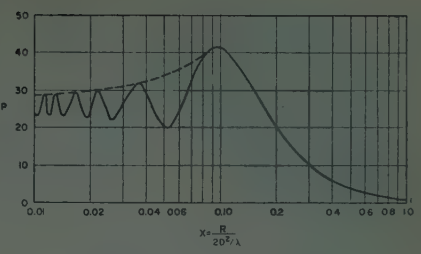

Fig. 5—On-axis power density, tapered circular aperture.

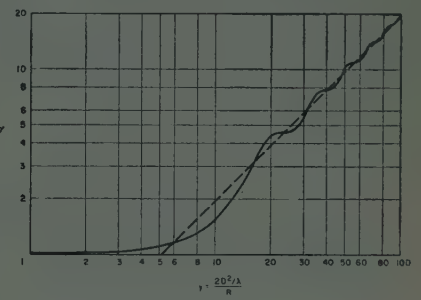

Fig. 6—Defocusing factor, tapered circular aperture.

$$P = \frac{16.2}{x^2}\left|\int_0^1 \exp\left[j\frac{\pi}{8x}(1-\xi^2)\right]\xi d\xi\right|^2$$

$$= 13.14\left(1-\cos\frac{\pi}{8x}\right) \quad (3)$$

which is plotted in Fig. 3 in fractions of $2D^2/\lambda$ with the power normalized to unity at $2D^2/\lambda$. The defocusing factor is

$$\gamma = \frac{\pi y}{8\sqrt{2}\sqrt{1-\cos\frac{\pi y}{8}}} \quad (4)$$

and is plotted in Fig. 4. Now

$$x = \frac{R}{2D^2/\lambda} \quad \text{and} \quad y = \frac{2D^2/\lambda}{R}.$$

At the points where the aperture subtends nearly an even number of Fresnel zones, the on-axis gain and power density both are zero.

Circular Aperture with $(1-\rho^2)$ Taper

This aperture is of most practical interest because it corresponds most closely with actual dish antennas. The power on-axis is given by

$$P = \frac{16.1}{x^2}\left|\int_0^1 (1-\xi^2)\exp\left[j\frac{\pi}{8x}(1-\xi^2)\right]\xi d\xi\right|^2$$

$$= 26.1\left[1 - \frac{16x}{\pi}\sin\frac{\pi}{8x} + \frac{128x^2}{\pi^2}\left(1-\cos\frac{\pi}{8x}\right)\right]. \quad (5)$$

A power density curve plotted from this equation is shown in Fig. 5. It may be noted that the peak power density occurs at about 0.1 $(2D^2/\lambda)$ and is nearly 42 times the $2D^2/\lambda$ density. The asymptotic value is 26.1. Similarly the defocusing factor is

$$\gamma = \frac{\pi y}{16\sqrt{1 - \frac{16}{\pi y}\sin\frac{\pi y}{8} + \frac{128}{\pi^2 y^2}\left(1-\cos\frac{\pi y}{8}\right)}} \quad (6)$$

* Received by the IRE, May 18, 1959.

[1] R. W. Bickmore, "On focusing electromagnetic radiators," *Can. J. Phys.*, vol. 35, pp. 1292–1298; 1957.

[2] M. K. Hu, "Study of Near-Zone Fields of Large Aperture Antennas," Final Rep. Contract AF 30(602)-928, Res. Inst., Syracuse Univ., N. Y.; April, 1957.

which is given in Fig. 6. Here the asymptotic value is

$$\gamma = \pi y/16.$$

The asymptotic curves of γ are useful in determining a Fresnel-Fraunhofer transition point which is defined[1] as the value of y at which asymptotic γ goes to unity. Note the following values:

$$\text{Square, uniform} \quad R = L^2/\lambda$$

$$\text{Circular, uniform} \quad R = \frac{\pi D^2}{4\sqrt{2}\lambda}$$

$$\text{Circular, tapered} \quad R = \frac{\pi D^2}{8\lambda}.$$

The power density on-axis in the Fraunhofer field at a distance of $2D^2/\lambda$ may be found from

$$\text{Power Density} = \frac{PG}{4\pi(2D^2/\lambda)^2} = \begin{cases} \dfrac{P}{4L^2} & \text{uniform square} \\ \dfrac{3\pi P}{64D^2} & \text{tapered circular} \\ \dfrac{\pi P}{16D^2} & \text{uniform circular} \end{cases} \quad (7)$$

where P = power and G = conventional gain.

Because the gain at $2D^2/\lambda$ is slightly smaller than the computed value which exists an infinite distance away, a small error of about 1 per cent is evident. For more accurate work (7) should be divided by the gain factor, γ, at $2D^2/\lambda$; this can be found from the appropriate Figs. 2, 4, or 6. (Note that this error may not be small[2] for other aperture distributions, particularly those with appreciable phase errors.) As an example, take an X-band dish with 25-db sidelobes, $\lambda = 3$ cm, $D = 20\lambda$, $G = 34.71$ db $= 2960$, and $2D^2/\lambda = 24$ m $= 78.75$ feet. Assume $P = 1000$ watts average.

$$\text{Power Density} = \frac{10^3 \times 2.96 \times 10^3}{4\pi \times (2.4)^2 \times 10^6} = 0.0408 \text{ watt/cm}^2. \quad (8)$$

Even this figure, for the maximum power density (on-axis) at the Fraunhofer distance of 79 feet, is well over the ARDC maximum[4] of 0.01 watt/cm^2. In the example the power density, from the envelope curve of Fig. 5, reaches a peak of $41.7 \times 0.0408 = 1.7$ watts /cm^2 at a distance of $0.096 \times 78.75 = 7.6$ feet. The gain reduction factor at 7.6 feet is $1.6^2 = 2.56$. The Fraunhofer beamwidth is 3.64°; at 7.6 feet it is approximately $3.64 \times 1.6 = 5.8°$.

The power density on the axis can be found from Fig. 6 by dividing γ^2 into $[(2D^2/\lambda)/R]^2$, because the Fraunhofer power density increases as R^2 while the gain reduction factor is γ^2. Thus, this is exactly equivalent to Fig. 5. Of course, the maximum power density only exists at a spot; for the example the peak power density is nearly 3 db down at an angle of $1/2(5.8°) = 2.9°$.

To summarize, the maximum power density is found by computing the density at $2D^2/\lambda$ from (7), and multiplying this value by the power factor from the envelope curves of Figs. 1, 3, or 5.

ACKNOWLEDGMENT

Data were computed by Carol Hasson.

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Spin-Spin Energy Transfer and the Operation of Three-Level Masers*

The original experiments on the three level maser[1] demonstrated the importance of the role played by spin-spin energy transfers. These occur whenever there is equality between two energy intervals, whether they belong to the same level scheme or to the level schemes of different spin species present in the material, and they may, by equalizing spin temperatures in the two intervals, profoundly modify the operation of the maser. In the course of recent experiments on paramagnetic relaxation in ruby (Cr^{+++} in Al_2O_3), we have observed a new type of transfer phenomenon which takes place when one energy interval is twice as large as another. This process is independent of temperature in the hydrogen-to-helium range and depends approximately on the square of the concentration. With 0.05 per cent Cr^{+++} the transfer times are of the order of a millisecond, which is long compared with the usual spin-spin times, but considerably shorter than lattice relaxation times at helium temperatures. The experimental evidence indicates that three spins are involved in the energy exchange, as compared with two in the usual type of spin-spin transfer. Consideration of the physical model suggests that this may be only the first in a sequence of higher order processes which become effective as concentration increases.

Spin energy transfers between intervals of different sizes introduces new difficulties and new possibilities in the design of solid state masers. In ruby, for instance, there are eleven ways in which one interval can be twice another (excluding the cases of equal adjacent intervals), and at an arbitrarily chosen setting there is an appreciable chance of working in the vicinity of a two-to-one frequency point. In this case, the two intervals concerned with tend to assume the same spin temperature, resulting in the imposition of a spurious load on the inverted spin group or the accidental cross pumping of levels and the destruction of the negative temperature. We have observed that the transfer effect spreads further to each side of the exact two-to-one setting as the concentration is raised, and it seems likely that this, complemented by higher order processes, may explain some of the difficulties encountered in the attempt to operate masers at higher spin concentrations.

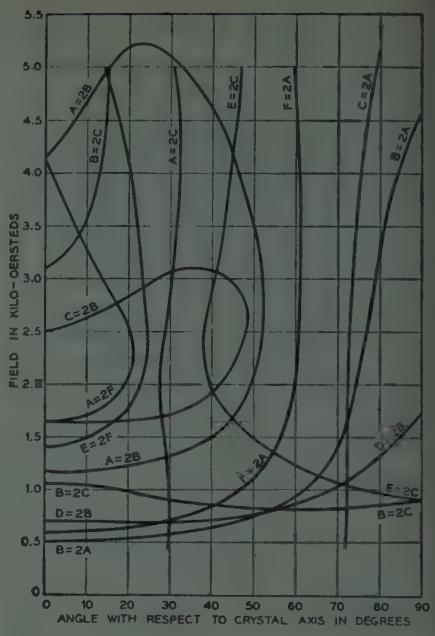

Fig. 1.

In other circumstances an advantage may be gained by communicating spin temperatures from one interval to another, particularly where the frequencies concerned are near the upper limit of those which can be generated by existing signal sources. For instance, a pumping temperature may be passed from a smaller to a larger gap; in the specially favorable case of $h\nu$ and $2h\nu$ intervals which are adjacent in the same level scheme, a signal at a frequency ν would serve to pump a $3h\nu$ gap. Spin mixing or "double doping" of the host lattice offers more complex possibilities such as two-stage multiplication of the effective pumping frequency, accelerated lattice relaxation, or the transfer of a negative temperature from a smaller to a larger interval. (Ordinary first order spin-spin transfer does not require that both spins belong to the same species, and there seems to be no reason why such a restriction should apply to higher order processes either.)

Fig. 1 shows angles to the crystal axis and magnetic fields for which there exists a two-to-one ratio between intervals in the ruby level scheme. If we number the ruby levels 1 to 4, starting with the lowest in energy the six intervals are designated by the following letters: A (1, 2), B (2, 3), C (3, 4), D (1, 4), E (1, 3), F (2, 4). The diagram was prepared from level schemes given by E. O. Schulz du Bois,[2] to whom the authors would like to express gratitude for the loan of the original graphs.

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[3] E. H. Braun, "Gain of electromagnetic horns," PROC. IRE, vol. 41, pp. 109–115; January, 1953.
[4] O. E. Horton, "Measurements of Radar Power Density Levels to Establish Non-Hazardous Working Areas," Wright Air Dev. Center Memo, WCLRS-6-58-4; March, 1958.

* Received by the IRE June 25, 1959.
[1] G. Feher and H. E. D. Scovil, "Electron spin relaxation times in gadolinium ethyl sulfate," *Phys. Rev.*, vol. 105, pp. 760–762; January, 1957.

[2] E. O. Schulz du Bois, "Parametric spectra of substituted sapphires," *Bell Sys. Tech. J.*, vol. 38, pp. 271–290; January, 1959.

Ridge Waveguide Impedance*

Consider single ridge waveguide of overall width a_1, overall height b_1, ridge width a_2, and ridge height b_2. Cohn[1] has shown that the cut-off wavelength λ_c' of the TE_{10} mode is determined by the lowest root (in $\theta_1+\theta_2$) of

$$\cot\theta_1 - (b_1/b_2)\tan\theta_2 = B_c/Y_1 \qquad (1)$$

where the phase angles θ_1 and θ_2 are defined by

$$\theta_1 = \pi(a_1 - a_2)/\lambda_c' \qquad (2a)$$

$$\theta_2 = \pi a_2/\lambda_c' \qquad (2b)$$

and B_c/Y_1 is the normalized equivalent susceptance at cutoff of the discontinuity. Cohn[1] has also given a formula for the characteristic impedance (voltage/current definition) of ridge waveguide, but he has partially neglected the effects of the discontinuity. Mihran[2] has shown how to correct Cohn's results to allow for the extra current flowing at the discontinuity, and his formula can be recast into a form that is more revealing and gives a simple, direct calculation of the characteristic impedance. Mihran's formula for the impedance at infinite frequency is

$$\frac{120\pi}{Z_{vi}\infty} = \frac{2C}{\epsilon_0}\cos\theta_2 + \frac{\lambda_c'}{\pi b_2}\left[\sin\theta_2 + \frac{b_2}{b_1}\cos\theta_2\cdot\tan\frac{\theta_1}{2}\right] \qquad (3)$$

where C is the capacity per unit length equivalent to the discontinuity. The term in C is that neglected by Cohn. This capacity may be related to the normalized susceptance of (1) by the result:

$$\frac{C}{\epsilon_0} = 120\pi c C = 120\pi\cdot\omega_c' C\cdot\frac{\lambda_c'}{2\pi} = \frac{1}{2\pi}\frac{B_c}{Y_1}\frac{\lambda_c'}{b_1}. \qquad (4)$$

Eliminating B_c/Y_1, (3) becomes:

$$Z_{vi}\infty = 120\pi(\pi b_1/\lambda_c')\sin\theta_1\cdot\sec\theta_2. \qquad (5)$$

Similarly, Mihran's formula for the characteristic impedance (power/voltage definition),

$$\frac{120\pi}{Z_{pv}\infty} = \frac{2C}{\epsilon_0}(\cos\theta_2)^2 + \frac{\lambda_c'}{4\pi b_2}\left[2\theta_2 + \sin 2\theta_2 + \frac{b_2}{b_1}\left(\frac{\cos\theta_2}{\sin\theta_1}\right)^2(2\theta_1 - \sin 2\theta_1)\right], \qquad (6)$$

may be simplified to

$$\frac{120\pi}{Z_{pv}\infty} = \frac{\lambda_c'}{4\pi b_2}\left[2\theta_2 - \sin 2\theta_2 + \frac{b_2}{b_1}\left(\frac{\cos\theta_2}{\sin\theta_1}\right)^2(2\theta_1 + \sin 2\theta_1)\right]. \qquad (7)$$

As a check we see that both (5) and (7) lead to the correct result for ordinary rectangular waveguide.

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* Received by the IRE, July 29, 1959.

[1] S. B. Cohn, "Properties of ridge wave guide," Proc. IRE, vol. 35, pp. 783–788; August, 1947.

[2] T. G. Mihran, "Closed- and open-ridge waveguide," Proc. IRE, vol. 37, pp. 640–644; June, 1949.

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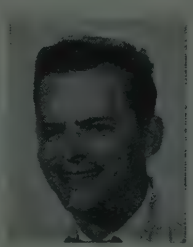

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As a research associate at Syracuse University from 1948 to 1956, he worked on infrared sources, thin film detectors, infrared background characteristics, and the electrical properties of living cells. He was an instructor of electronics and advanced general physics from 1951 to 1953. He joined the Philco Corporation, Philadelphia, Pa., in 1956, and is presently a research group supervisor engaged in the investigation of infrared devices.

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Thomas J. Rey was born on January 1, 1918, in Berlin Germany. He was educated at the College Francais in Berlin, and at the University of London, England, where he received the B.S. degree in engineering in 1938, the B.A. degree in mathematics in 1947, and the M.A. degree in mathematics in 1950.

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Scanning the Transactions

Is space exploration economically justified? There is no question that the scientific gains from our exploits in space will be tremendous, but what is this going to cost in dollars and cents? Before answering that question, however, one must also consider what it would cost *not* to probe space. In this connection one authority has the following to say: "First, the success of the early Sputniks has probably cost the United States at least five billion dollars which will be paid for in lost contracts on the world market, additional military and economic aid to our allies, and increased demonstrations of the United States military and economic might. Second, it can be shown that it is more economic to use communication satellites for world communications than to use any other technique when the channel capacity desired approaches that of television or greater. The capital investment involved for such communications is about three hundred million dollars. Third, during the past year there has been increasing interest by commercial organizations in sponsoring their own satellite program for purely commercial gain. The concerns would even buy the vehicles."

His somewhat surprising conclusion: Space exploration will probably pay for itself. (E. Rechtin, "Communication techniques for space exploration," IRE TRANS. ON SPACE ELECTRONICS AND TELEMETRY, September, 1959.)

Transatlantic radio via airborne relays? Midst all the current discussion of using earth satellites for long range communication comes the following interesting alternative, proposed in a guest editorial in a recent issue of the PGCS TRANSACTIONS. "The development of a transmission facility for spanning distances of 400 to 2400 miles or greater is required for carrying multichannel information of the type now transmitted on transcontinental radio relay links. Both the high-powered tropo and the communications satellite pose partial solutions to this problem; however, the attendant problems, including that of interference, make some other solution desirable. One such approach would be the development of a high-altitude airborne relay platform capable of sustained operation for periods of days on location. The manpower requirement for such an operation should be less than that required for equivalent number of tropo stations, and at the same time, the lower transmitted powers required plus the use of directional antennas should provide a facility which is much less susceptible to causing or receiving radiated interference. In this case, the solution probably lies in the labs of the nuclear powered air frame designer and provision of this capability must await advances in this field." (C. A. Strom, Jr., "Editorial," IRE TRANS. ON COMMUNICATIONS SYSTEMS, September, 1959.)

With Information Theory a little over 10 years old what assessment can be given past accomplishments and future prospects in this field? One distinguished observer sums it up as follows. For one thing, Information Theory has now become mathematically respectable. At the same time, practical achievements have fallen short of what could be expected ten years ago. Most progress has been made where communications were already near-perfect. On the other hand, hardly any progress has been made in the filtering of speech, or in the transmission of speech or pictures in reduced wavebands, where the potential saving is not measured in percents but in orders of magnitude. But until we know more exactly what it is that a human ear picks out in a conversation with a noisy background, or what the eye picks out at a glance in a picture, no serious progress is possible, except perhaps by lucky inventions. There is a gap of a million or so between the 20 bits per second which the human eye is capable of taking in, and what we offer it in a television picture. It would seem that at least the first two orders of magnitude out of the six ought to be relatively easy going, and could be overcome on the basis of such elementary knowledge as that the eye fixes in the first line on contours, and samples what is in between. This is a challenging problem for the signal analyst, who must first pioneer the field before statistical communication theory can start. If more effort is directed into the No-Man's Land between raw sensory data and the distinguishable signals which are the starting point of the statistical theory, the second decade of Information Theory will be as rich in practical improvements in communication techniques as the first was in intellectual clarification. (D. Gabor, "Guest editorial," IRE TRANS. ON INFORMATION THEORY, September, 1959.)

Recent developments in FM signal-processing techniques have removed a basic limitation of FM—the stronger-signal capture effect whereby the desired signal is blotted out by a stronger cochannel or adjacent-channel signal. The two techniques of "feedforward" across a limiter and "dynamic trapping" now make it possible to extract the weak signal, as well as the strong one, opening up a number of interesting possibilities. A weak signal and a strong signal could be sent on separate carriers within the same FM channel, thus doubling the number of messages that can be sent over one channel. For example, a stereo program could be broadcast, or a simultaneous exchange of voice messages could be carried on, in one channel. In telemetry, the presently wasted frequency guard spaces could be put to use. In addition, the weaker-signal booster can be changed into a weaker-signal suppressor, thus greatly improving the stronger-signal capture characteristics of FM receivers. (E. J. Baghdady, "New developments in FM reception and their application to the realization of a system of power-division multiplexing," IRE TRANS. ON COMMUNICATIONS SYSTEMS, September, 1959.)

Automatic diagnosis of heart conditions has been shown to be possible with a new electrocardiographic recording and data reduction system. The system provides for the taking of simultaneous measurements at as many as 100 points on the body, instead of just the usual three or four, to give a more nearly complete picture of the electrical activity of the heart. These readings, in addition to being recorded, are compared with records of known heart conditions by means of cross-correlation techniques. A chart reading system feeds the information being recorded to a cross correlator. At the same time, a continuous loop motion picture film containing records of prediagnosed heart conditions is run and scanned electronically to provide a second input signal to the cross correlator. The signals are compared and, unless the readings are insufficient, a diagnosis is thus established entirely automatically. (J. Martinek, G. C. K. Yeh and R. Carnine, "A new system for electrocardiographic recording, analysis, and diagnosis," IRE TRANS. ON MEDICAL ELECTRONICS, September, 1959.)

The prospect of manned space flight poses some challenging problems for those who must design the space communication system. A noted space biologist, who will be remembered for his suggestion that for better efficiency a space crew might comprise two men and one woman, reminds us that the presence of passengers on board a space vehicle will greatly increase the amount of information that must be telemetered to earth. Not only must the crew and ground

personnel be able to communicate back and forth, but a wide variety of environmental and behavioral data must be transmitted to earth. For example, earthlings will want to measure: cabin pressure, oxygen and carbon dioxide content of cabin atmosphere, cardiac activity of the crew, respiratory rate and volume, blood pressure, electroencephalographic data, muscle activity, reflex activity, galvanic skin response, body temperature, activity of the gastrointestinal tract, food and water intake, and urine and feces excretion. It seems clear that the design of space communication systems of the future will require the talents of biophysicists as well as electronics engineers. (T. C. Helvey, "Telemetered parameters of primates and humans from space capsules," IRE TRANS. ON SPACE ELECTRONICS AND TELEMETRY, September, 1959.)

The pioneers in circuit theory are beginning to stake out boundaries marking substantial advances in the analysis and synthesis of linear networks with time-varying parameters. The growing use of time division as a means of switching and multiplexing has made the problem of efficient transmission from source to load through a variable intermediate path one of great practical interest. The September, 1959 issue of the PGCT TRANSACTIONS includes two contributions to this field. One paper analyzes a general linear network containing a single periodically varying element. The steady-state modulation theory approach is combined with techniques of impedance matching, circuit tearing, and iterative procedures. The other paper deals with a periodically operated switch in a linear circuit. It differs from earlier work in this field by concentrating on the system function rather than on the network structure. (C. A. Desoer, "Steady-state transmission through a network containing a single time-varying element," and A. Fettweis, "Steady-state analysis of circuits containing a periodically-operated switch," IRE TRANS. ON CIRCUIT THEORY, September, 1959.)

The value of advertisements in the PROCEEDINGS is, in the eyes of our advertising manager, unquestionable and irrefutable. They are also technically informative, widely read and frequently acted upon, he is always happy to explain. And we are happy to agree. Just how valuable, informative, etc., is now attested to in a most singular fashion. An ad has been cited as a technical reference in a technical paper—in fact, two ads. The ads in question deal with the timely subject of noise temperature and appeared on page 2A of the January and May, 1958 issues of the PROCEEDINGS as part of a series of informative technical discussions which now appear monthly on page 4A. We strongly suspect that this is the first time in the history of any engineering periodical that an ad has served, and ably so, as a footnote reference. (S. Perlman, *et al.*, "Concerning optimum frequencies for space vehicle communication," IRE TRANS. ON COMMUNICATIONS SYSTEMS, September, 1959.)

Books

Paris Symposium on Radio Astronomy, Ronald N. Bracewell, Ed.

Published (1959) by Stanford University Press, Stanford, Calif. 601 pages+10 index pages+xii pages. Illus. 6¼×9¼. $15.00.

The Paris Symposium on Radio Astronomy was held in Paris in August, 1958, and was jointly sponsored by the International Astronomical Union and the International Scientific Radio Union. All astronomical aspects of radio astronomy were covered except those pertaining to meteors and the ionosphere. Instrumentation and techniques were not specifically treated since they were covered in 1957 at the General Assembly of the International Scientific Radio Union in Boulder, Colo.

In the words of its able editor, R. N. Bracewell, "This book records the research results reported at the symposium as subsequently submitted with benefit of revision; and, together with the several introductory surveys, the extremely good discussions, and the concluding assessments, it forms a comprehensive account of the current state of development of the basic aspects of radio astronomy."

Over 100 invited papers from 13 countries were presented to 162 astronomers and other scientists from 17 countries. These papers were given in six nonconcurrent sessions (totaling 60 hours) under the following subjects and session organizers:

1) Radio emission and reflections from planets, comets and the moon: A. C. B. Lovell.
2) Solar radio emission and the quiet and active sun: J. F. Denisse.
3) Radio study of individual objects (external to solar system): H. C. van de Hulst.
4) Radio evidence on the large-scale structure of our own and external galaxies: J. L. Pawsey.
5) Source surveys, identifications, and other studies related to cosmological problems: R. Minkowski.
6) Theory, mechanisms of solar and cosmic radio emission: Fred Hoyle.

The over-all planning of the Symposium was under the direction of the following committee: R. N. Bracewell, editor; J. F. Denisse, local organizer; F. T. Haddock, secretary; F. Hoyle; H. C. van de Hulst; A. C. B. Lovell; R. Minkowski; J. L. Pawsey, chairman; V. V. Vitkevich.

Each session was opened with an introductory speaker (F. G. Smith, J. F. Denisse, J. S. Hey, J. L. Pawsey, R. H. Brown, and G. R. Burbidge, respectively) who made a survey of the field to be covered by his session. In addition, at the end of each session a summary talk was given by an astronomer (A. C. B. Lovell, M. G. J. Minnaert, H. C. van de Hulst, A. Blaauw, R. Minkowski, and F. Hoyle, respectively) who attempted to point out the highlights of the papers presented in his session, and to point out the areas of agreement and of disagreement in the topics discussed. These introductory and summary papers can be read by the nonspecialist for an up-to-date review of the astronomical side of radio astronomy.

The discussion following each paper, or group of related papers, was written down on the spot, then later checked and edited. This is a valuable feature and gives the reader the kind of information not usually available in the literature.

Other outstanding features of this book are its speed of publication and its excellent and copious illustrations. It appeared in less than one year after the Symposium in spite of the 137 separate authors of 106 papers, including 8 in French. The editor and Stanford University Press are to be commended for this achievement.

Some 500 recent papers cited in this volume comprise an up-to-date bibliography on radio astonomy. A list of participants with their addresses, an author key to all references, and a detailed index of subject and authors are also included.

This volume will be a constant reference for the active radio astonomer for a number of years and will serve the interested engineer as an introduction to the astronomical side of the subject.

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From Microphone to Ear: Modern Sound Recording and Reproduction Technique, 2nd Rev. Edition, by Gerard Slot

Published (1959) by The Macmillan Co., 60 Fifth Ave., N. Y. 11, N. Y. 246 pages+4 index pages+8 appendix pages. Illus. 5½×8. $4.50.

This book presents a survey of the entire field of high-fidelity sound recording and reproduction from an engineer's point of view, but in language intelligible to the layman. The writing and organization are excellent, and the book may be "read through" with pleasure.

It should be of primary value to the high-fidelity hobbiest. However, it may also be of great value to professional workers in a small area of this broad field who wish to become better acquainted with other areas.

A rather minor complaint is the lack of a satisfactory description of the coordinates of several graphs. Fortunately, the text is usually sufficiently clear to enlighten the reader when the coordinate functions are missing.

The author is in charge of technical publications for the Philips Apparatus Division, Eindhoven, Holland. The book is translated from Dutch.

DAVID L. KLEPPER
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Technical Reporting Revised, by Joseph N. Ulman, Jr., and Jay R. Gould

Published (1959) by Henry Holt and Co., 383 Madison Ave., N. Y. 17, N. Y. 246 pages+6 index pages+3 bibliography pages+12 Appendix pages +xvii pages. Illus. 6¼×9¼. $5.00.

Effective technical reporting is a vital necessity if we are to continue our rapid advances in science and technology. It is, therefore, refreshing to examine a book which can lead the reader to report on his technical findings in a clear, lucid manner. Here is a book which gives detailed help and instructions on all the many aspects of communications, whether such communications are by means of written or spoken words, or by means of visual presentations.

Designed as a basic text for courses in technical writing for students of engineering and the sciences, it has been through the proving ground of extensive classroom use. It is a revised and expanded version of a previous text.

There are three main parts to the book—Basic Issues, The Report, and Tools and Methods. Each of these in turn is divided into numbered and titled sections and subsections, making it easy to select rapidly a specific topic of interest.

Under the main heading "Basic Issues" appear such subjects as fundamental principles, which presents very completely and in considerable detail the main points to keep in mind when preparing a written report. Included are very helpful hints on such matters as how to be brief, the use of headings and subheadings, organization, and the like. Also in this first part are suggestions as to the various steps to follow in preparing a report.

The second portion of the book discusses various types of reports—informal, formal, and laboratory reports, the thesis, technical articles, instructional writing, and oral presentations. Again, each type is covered in detail, and much helpful information is presented—including warnings of the pitfalls normally encountered in such presentations.

Part three, titled "Tools and Methods," might easily be called the "handbook" portion of the book. Here are specific, detailed instructions on style, grammar and punctuation. Here can be found the answer to many of the problems that arise in the preparation of written or oral presentations—split infinitives, the dangling modifier, proper use of commas, etc. Extensive use is made of examples to illustrate various points.

Also included in part three is a section on the mechanics of writing—use of abbreviations, quotations, page numbering, margins, etc. A section on tables tells how they can best be presented and where they are most useful. Then there is an important section on visual aids, with lots of "how to" information to obtain maximum effectiveness from the use of such aids.

The Appendix contains a number of specimen reports of various kinds to show the many possible ways of presenting technical information. A bibliography is included for those who wish to pursue the subject further.

Scattered throughout the book are many exercises which, if worked out, will aid the reader in applying the principles outlined in the text material. Thus, these principles become a part of his stock in trade, and he gradually learns to use them automatically.

Here, then, is a book which can be of tremendous help to the beginner in the field of technical writing, and can be a valuable reference to the many "professionals" in the field.

H. S. RENNE
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Elements of Solid State Theory, by Gregory H. Wannier

Published (1959) by Cambridge University Press, 32 E. 57 St., N. Y. 22, N. Y. 258 pages+12 index pages+12 index pages+vii pages. Illus. 5¾×8¼. $6.50.

This book is designed as an introduction to the theory underlying solid state physics. It is intended for advanced students and scientists who have had no previous exposure to this specialty. Actually, this slim volume should appeal to a much wider audience than this, since it treats the rudiments of solid state theory in a highly individualistic manner, with a degree of maturity and sophistication rarely found in introductory textbooks.

Wannier's book is less comprehensive but more thought-provoking than such standard texts as "Solid State Physics" by Dekker, "Introduction to Solid State Physics" by Kittel, or "Electronic Semiconductors" by Spenke. The present book is most similar in spirit and coverage to "Quantum Theory of Solids" by Peierls.

Among the several topics treated are the following: geometry of the crystalline state; dynamics of lattice vibrations (with just a touch of group theory and topology added for taste); co-operative phenomena in solids; the one-electron approximation; electronic energy bands; bound carrier states; carrier dynamics; electronic transport processes; and solid cohesion and chemical bonding. Each chapter concludes with an excellent choice of problems and references for further reading.

Wannier is admirably successful in sketching the "broad picture;" he never gets bogged down in the details. His discussion is generally lively and physically motivated. There is a very happy balance between mathematical exposition and straight narrative.

As a typical example of Wannier's physical insight, we might mention his treatment of the electrical conductivity tensor of pages 208 and 209. While most texts[1] end up with the following expression:

$$\sigma = -e^2 \int \partial f_0/\partial E \tau(p)\ \mathrm{grad}_p E(p)\ \mathrm{grad}_p E(p) dp, \quad (1)$$

Wannier goes one step further, and, integrating by parts, obtains the equivalent result:

$$\sigma = +e^2 \int f_0(p)\ \sigma \mathrm{rad}_p [\tau(p)\ \mathrm{grad}_p E(p)] dp. \quad (2)$$

With this form, it is possible to determine the contribution of the carriers in an arbitrary volume element dp to the conductivity tensor, since here σ is expressed as an average over the equilibrium distribution f_0, rather than as an average over the derivative of this distribution. For simplicity, let us specialize to a universal relaxation time [$\tau(p)=\tau$ for all p]. Then (2) reduces to:

$$\overline{\sigma} = e^2\tau \int f_0(p)\ \mathrm{grad}_p [\mathrm{grad}_p E(p)] dp$$
$$= e^2\tau \langle [m^*(p)]^{-1} \rangle, \quad (3)$$

where $\langle\ \rangle$ denotes an average over the equilibrium distribution, and $[m^*(p)]^{-1}$ is the reciprocal effective mass tensor, It is now easy to see that particles in negative mass states give negative contributions to the conductivity tensor. In this reviewer's opinion, the above demonstration is more straightforward than several others that have recently appeared.

Summing up, Wannier's book is a valuable addition to the literature on solid state physics, particularly from the standpoint of the more discriminating reader. It seems well suited as a textbook for use in introductory courses for students and scientists having good mathematics and physics backgrounds.

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Fundamentals of Electron Devices and Circuits, by Herman R. Weed and Wells L. Davis

Published (1959) by Prentice-Hall, Inc., 70 5th Ave., N. Y. 11, N. Y. 584 pages+7 index pages+xii pages. Illus. 6¼×9¼. $9.50.

This very readable, easily understood book on electron devices and circuits is sufficiently advanced for undergraduate electrical engineers, yet well within the grasp of nonelectrical engineering students. One may wonder whether both these goals can indeed be realized in a single text. The secret of doing so lies in introducing each topic in terms of its broad fundamental concepts before developing its more complex details. When done in proper balance, this makes for understanding that is "broad" for nonelectricals, "complete" for electricals.

The authors have applied good logic not only to the sequence of thoughts in each topic, but also to the sequence of topics in each chapter and the sequence of chapters in the book. For example, in the chapter entitled "the Triode," the progression of

[1] See, for example, A. H. Wilson, "The Theory of Metals," Cambridge University Press, second edition, page 196, 1953.

topics is as follows: triode construction, potential distribution in a diode without space charge, potential distribution in a diode with space charge, potential distribution in parallel plane triode, the triode as a circuit element, plate resistance, amplification factor, transconductance, relation between tube parameters, etc. Those familiar with triode theory will recognize the logical order of these topics. The same comment applies to the chapter progression: Electric Circuits, Electron Emission and Acceleration, The Diode, Single-Phase Rectifier Circuits, Polyphase Rectifiers, Semiconductor Diodes, The Triode, Class A Amplifiers, Multigrid Tubes, Direct Coupled, Push-Pull, and Feedback Amplifiers; Transistor Circuits, Magnetic Amplifiers, Gas Tube Characteristics, Basic Gaseous Tube Circuits, Controlled Rectifiers, Back-to-Back Circuits and Inverters, Industrial Timing Circuits, Regulators, Operational Amplifiers, Oscillators, Electronic Instruments, and Phototubes and Applications. Such an integrated sequence is particularly valuable to the reader with minimum preparation (say a working knowledge of calculus and elementary college background in electrical physics). Yet the degree of integration practiced in this book does not prevent the more advanced reader from "spot-reading" its contents effectively. Suffice it to say that the flow pattern of the material presented in the text is excellent.

Various improvements could be made in the text, one of which would be to add a more comprehensive list of references. The book would then attract an additional audience, namely, the practicing engineer who often desires a quick introduction or review of some subject plus convenient references to more advanced works. The chapter on semiconductor diodes could be improved by expanding the section on germanium and silicon diodes, even if this required some reduction in the material on copper-oxide and selenium diodes. Also, somewhat further use of semiconductor diodes and transistors in circuit examples would make the text more in keeping with present trends in the art. In the sections on feedback, the reader is led to the general belief that inverse feedback may be used only to increase, not decrease, the input impedance of an amplifier. This fallacy should be cleared up in future editions of the book. By and large, these criticisms, and others that might be made, are rather trivial matters, many of which are controversial.

All in all, the book offers a clear and concise treatment of a broad range of topics. It should find effective use, particularly in the instruction of undergraduate engineers.

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Murray Hill, N. J.

RECENT BOOKS

Carroll, John M., ed., *Modern Transistor Circuits*. McGraw-Hill Book Co., Inc., 330 W. 42 St., N. Y. 36, N. Y. $8.50.

Champion, F. C. and N. Davy, *Properties of Matter*, 3rd ed. Philosophical Library, N.Y. $10.00. The important change in this new edition is the gradual orientation of the subject from a largely phenomenological treatment to atomic interpretations.

Eichner, Hans and Hans Hein, *Reading German for Scientists*. John Wiley and Sons, Inc., 440 Fourth Ave, N.Y. 16, N.Y. $5.25. This book is designed to serve the needs of the student who wants to be able to read German scientific texts and wishes to reach this limited aim by the shortest route.

Evans, Ralph M., *Eye, Film and Camera in Color Photography*. John Wiley and Sons, Inc., 440 Fourth Ave., N.Y. 16, N.Y. $8.95. Considers the optical photographic and physical bases, the psychological facts that apply in using a camera, and the way in which they may be combined to aid the various purposes of the photographer.

Gillie, Angelo C., *Transistors*. Prentice-Hall, Inc., 70 5th Ave., N. Y. 11, N. Y. $7.95. From general linear and nonlinear conduits, to nonlinear resistive control devices, to the transistor and its applications. Requires a minimum of mathematics.

Kiver, Milton S., *Transistors in Radio, Television and Electronics, 2nd ed.* McGraw-Hill Book Co., Inc., 330 W. 42 St., N. Y. 36, N. Y. $7.95. A revised edition of the original text, which was reviewed earlier in the PROCEEDINGS.

Levens, Alexander, F., *Nomography*, 2nd ed. John Wiley and Sons, Inc., 440 Fourth Ave. N. Y. 16, N. Y. $8.50. Provides a modern working knowledge of the basic theory and construction of charts involving straight line scales, curved scales, and combination of the two.

Mark, David, *R-L-C Components Handbook*. John F. Rider Pub., Inc., 116 W 14 St. N. Y. 11, N. Y. $3.50. The purpose of this book is to inform the reader about various factors of importance in selecting a resistor, capacitor, inductor, or transformer and to acquaint him with the various types of available components and their special features.

Proceedings of the Fourth National Conference on Tube Techniques. New York University Press, Washington Sq., N. Y., N. Y. $7.50.

Ritchie, Ralph W., *Microwave Measurements for the Technician*. Wm. C. Brown Co., Dubuque, Iowa. $3.50. A comprehensive, simplified manual on basic microwave measuring techniques, especially helpful to electronics engineers and technicians with little or no previous indoctrination in the field.

Smith, Charles V. L., *Electronic Digital Computers*. McGraw-Hill Book Co., Inc., 330 W. 42 St. N. Y. 36, N. Y. $12.00. A study based on the Institute of Advanced Studies computer, of value to the newcomer to the computer field.

Warfield, John W., *Introduction to Electronic Analog Computers*, Prentice-Hall, Inc., Englewood Cliffs, N. J. $6.00.

Williams, Samuel B., *Digital Computing Systems*. McGraw-Hill Book Co., Inc., 330 W. 42 St., N. Y. 36, N. Y. $7.75. Describes the structure of modern computing systems selected "hardware" and application in simple terms.

Abstracts of IRE Transactions

The following issues of TRANSACTIONS have been recently published, and are now available from the Institute of Radio Engineers, Inc., 1 East 79th Street, New York 21, N. Y., at the prices indicated. The contents of each issue and, where available, abstracts of technical papers, are given herewith.

Sponsoring Group	Publication	Group Members	IRE Members	Non-Members*
Circuit Theory	CT-6, No. 3	$1.45	$2.15	$4.35
Communications Systems	CS-7, No. 3	2.15	3.25	6.45
Electron Devices	ED-6, No. 3	1.10	1.65	3.30
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Space Electronics and Telemetry	SET-5, No. 3	1.45	2.15	4.35

* Libraries and colleges may purchase copies at IRE Member rates.

Circuit Theory

Vol. CT-6, No. 3, September, 1959

Abstracts (p. 242)

Steady-State Transmission through a Network Containing a Single Time-Varying Element—C. A. Desoer (p. 244)

This paper presents a method of steady-state analysis of a linear network, of arbitrary degree of complexity, containing a single periodically-varying element. The proposed method makes full use of circuit theoretical ideas, such as impedance matching and tearing apart, and of teration techniques which are particularly suitable for automatic computation. The proposed method has the additional feature of leading to the amplitude and phase of *all* sidebands and of giving a bound on the error if the iterations are stopped at any particular point. More precisely, it is shown that, provided the impedance seen by the time-varying element becomes capacitive at very high frequencies, the complete solution can be found within an arbitrary amount of accuracy.

Steady-State Analysis of Circuits Containing a Periodically-Operated Switch—Alfred Fettweis (p. 252)

The exact conversion functions are calculated for networks containing one periodically operated switch, using familiar pole-zero and Fourier methods of analysis. It is first assumed that the switch is alternately open and closed during equally long time intervals. Circuits whose driving-point impedance $Z(p)$ seen from the switch has neither pole nor zero at infinity are treated in detail. The analysis is then extended in order to allow for impedances $Z(p)$ having either a pole or a zero at $p=\infty$. Complete results are also given for circuits whose switch is alternately open during time intervals of duration, T_1, and closed during intervals of duration, $T_2 \neq T_1$.

The general analysis is applied to a series modulator and the realization of a given function of frequency as conversion function of such a modulator is investigated.

Throughout this paper, the impedance $Z(p)$ is assumed to have only simple poles and simple zeros.

On a Problem of Network Topology—Toshio Fujisawa (p. 261)

In mesh-basis analysis of networks with mutual and active elements, it is necessary to list all possible trees or cotrees and signs of cotree determinants. This paper provides a computational method for obtaining them.

Computations are based on fundamental circuit matrices. A transformation from one tree to another tree may be performed by elementary transformations on circuit matrices. By this method, all the trees and fundamental circuit matrices may be determined. Signs of cotree determinants and their minor determinants of a fundamental circuit matrix also may be easily determined.

The Path Matrix and Its Relizability—O. Wing and W. H. Kim (p. 267)

This paper presents in one listing those properties of the path matrix of a graph which are fundamental and interesting in nature. Included are 1) a relation between the path matrix and the incidence matrix, 2) the rank of the path matrix, 3) relations between paths and cut sets, and 4) relations between paths and circuits (Ashenhurst's lemmas). Also included are a number of necessary conditions for the realizability of a matrix as a path matrix of a graph.

The Problem of Phase Equalization—G. Szentermai (p. 272)

The equalization of the insertion-phase vs frequency characteristics of low-pass filters and low-pass like networks is considered in the article. A method is described for maximally-flat equalization by minimum-pass or all-pass equalizers. The method can be readily extended to a nearly equal-ripple approximation by using Darlington's method of Tchebycheff polynomial series.

Optimum Filters of Even Orders with Monotonic Response—Minoru Fukada (p. 277)

Recently, Papoulis has developed a new class of filters, which has the maximum cutoff rate under the condition of a monotonically-decreasing response. These new filters are based on the optimum monotonically-increasing polynomials of odd degrees. In this paper, the optimum polynomials of even degrees are presented in general forms, from which the optimum filters with monotonic response are derived. Characteristics of these filters are illustrated by several examples which include frequency response, pole locations and the ladder realizations.

A Note on Zeros of Reflection and Transmission in a Cascade of Lossless Two-Terminal-Pair Networks—Daniel C. Fiedler (p. 282)

Certain properties of cascade-connected, two-terminal-pair lossless networks are investigated. Particular reference is made to the duo-cascade (two-terminal-pair networks) and the trio-cascade (three two terminal-pair networks).

In the first part of the paper, theorems and proofs pertaining to inter-relations among the reflection and transmission coefficients of the complete cascade and the two-terminal-pair networks are presented. In the second part of the paper, a discussion of degenerate transmission zeros is presented. In the third section, the effects on transmission coefficients of adding various right-half s-plane zeros of reflection are investigated. Reflection zeros are added so that the real frequency magnitude of a reflection coefficient is invariant under the addition of reflection zeros.

Network Realizability in the Time Domain—Armen H. Zemanian (p. 288)

Two network-realizability theorems on the unit-impulse response matrix of a multiterminal network are developed. They present necessary and sufficient conditions which are satisfied by the unit-impulse response matrix of certain classes of fixed, linear, and passive networks.

Envelope and Angle Response of Asymmetrical Narrow-Band Networks—Julius J. Hupert (p. 292)

This paper outlines a general approach to the evaluation of envelope and angle response of narrow-band networks including asymmetrical networks. From a known constellation of poles and zeros of a network in the s-plane, approximate linearized transfer functions are developed which relate envelope and angle response of the network to the amplitude modulation of the forcing function for small signal conditions (shallow modulation). The transfer functions are expressed in terms of two auxiliary constellations in the p-plane, where p is equivalent to the complex frequency of modulation.

Optimization of Negative-Impedance Conversion Methods of Active RC Synthesis—Isaac M. Horowitz (p. 296)

Negative-impedance conversion methods of active RC synthesis lead to networks which are highly sensitive to active and passive parameters. In the design of such networks there is some freedom available, which may be used to minimize the sensitivity of the structure to both the active and passive parameters. In most cases, the problem is that of decomposing a polynomial with real coefficients into the differences of two polynomials with negative real zeros such that the latter two polynomials have coefficients which are as small as possible. The optimum design is presented.

DC Design of Resistance-Coupled Transistor Logic Circuits—W. J. Wray, Jr. (p. 304)

Worst-case dc design equations for resistance coupled transistor logic circuits are presented and discussed. A solution is chosen in a form which provides for setting switching transient times in advance of calculating the dc design. All constants are discussed, and the algebraic solution is obtained for values of the unknown resistors and voltages. A numerical example illustrates a typical design with five inputs and five outputs, using the type GT-759 transistor.

RC Constant-Argument Driving-Point Admittances—Ralph Morrison (p. 310)

This paper deals with a class of RC driving-point immittances characterized by nearly constant argument over an extended frequency range. These arguments may have an average value between the limits zero and $\pi/2$ radians. Networks having near constant argument are of importance in shaping the phase character of the forward gain in feedback systems. These networks have arguments that oscillate about a mean value and the nature of this oscillation is discussed. The poles of admittance are geometrically spaced along the negative-real frequency axis, and consequently the elements of the network can be thought of as "spaced." The immitance functions and argument oscillations for the $22\frac{1}{2}°$, 45° and $67\frac{1}{2}°$ cases as a function of spacing are fully discussed. An application to a feedback amplifier design is given.

Correction to "Bounded Real Scattering Matrices and the Foundations of Linear Passive Network Theory"—D. C. Youla, *et al.* (p. 317)
Reviews of Current Literature (p. 318)
Correspondence (p. 321)
PGCT News (p. 326)

Communications Systems

Vol. CS-7, No. 3, September, 1959

Frontispiece and Guest Editorial (p. 145)

New Developments in FM Reception and Their Application to the Realization of a System of "Power Division" Multiplexing—Elie J. Baghdady (p. 147)

Two techniques—*feedforward* across a limiter and *dynamic trapping*—are described to show how the message carried by the weaker of two cochannel FM signals can be extracted with negligible distortion even when its amplitude is much smaller than that of the stronger signal. The development of these techniques marks the end of the stronger-signal capture limitation of FM systems and ushers in more efficient spectrum utilization, as well as new applications for frequency modulation.

Probability Distribution of Noise Due to Fading on Multisection FM Microwave-Systems—Harold E. Curtis (p. 161)

The probability distribution of expected baseband noise during fading at the end of a multisection microwave radio system is an important consideration in the engineering of a long system.

This paper gives measurements of fading on a single path, and derives an estimate to the probability distribution of expected noise due to fading on a particular 68-section system of which the single path is a typical part. A comparison is shown with a measured cumulative distribution curve of noise at baseband subsequently obtained on the long system under operating conditions. A numerical method of combining distribution curves was used in this case and the so-called "breaking effect," due to deep fades, is included. This method is described in the Appendix. While this paper is directed specifically to a particular microwave system, the principles described can be applied equally well to others.

Concerning Optimum Frequencies for Space Vehicle Communication—S. Perlman, *et al.* (p. 167)

Optimum frequencies for the varied needs of space vehicle communication can best be determined from the estimated system performance. Each of the contributing equipment and propagation factors over the range of the radio frequency spectrum affects the minimum tolerable signal-to-noise power ratio at the receiver. Over the range of the radio frequency spectrum, the behavior of the individual building blocks, as factors, will vary so as to exhibit a preponderance of either desirable or undesirable characteristics.

Some of the newer technical developments that increase sensitivity to weak signals are evaluated for their potential increase in the distance of communication. Then the individual building blocks are married to each other in operating systems that determine the optimum portions of the frequency spectrum. The equipment factors are examined first, both as to their individual characteristics and their dependence on each other. Next, the propagation factors are examined for their effect over the range of the radio frequency spectrum in providing windows for communication through the earth's atmosphere, troposphere, and ionosphere to outer space. Some consideration is given to the effects of auroral displays, water vapor and gaseous absorption, Faraday rotation of polarization, and radio star scintillations. In addition, there is a discussion of noises arising from various causes. Measurements by radio astronomers demonstrate that equivalent noise temperature is a more useful measure of signal-to-noise ratio of receiver performance than the standard noise figure definition.

Effects of Frequency Cutoff Characteristics on Spiking and Ringing of TV Signals—A. D. Fowler and J. C. Igleheart (p. 173)

The spiking and ringing of TV signals depend upon amplitude and delay characteristics associated with frequency cutoff of transmission. The effects of a variety of cutoff characteristics of both ideal and practical systems on rectangular and sine-squared pulses are illustrated by computed waveforms.

The illustrations are arranged to show a) waveform of input pulse, b) amplitude and delay characteristics of transmission path, and c) waveform of output pulse. Included here is a discussion of inferences that can be drawn from certain output wavesforms on the reductions in transient response that are achieved by inband delay equalization and amplitude roll-off.

A 2500-Baud Time-Sequential Transmission System for Voice Frequency Wire Line Transmission—G. Holland and J. C. Myrick (p 180)

The Sebit-25 is a full duplex terminal equipment designed to transmit digital data at rates up to 2500 baud. The equipment has been completely transistorized and thoroughly evaluated under environmental conditions.

In operation, binary information at 2500 baud is converted to minimum bandwidth and used to amplitude modulate a 2500-cycle carrier. The resulting signal is converted to vestigial sideband prior to transmission, to further compress the bandwidth.

At the receiver terminal, amplitude and delay compensation are provided to correct for distortion introduced by the transmission line. Synchronous sampling of the recovered signal by a slaved time standard reproduces the original binary information even though line distortion may be severe.

Excellent performance results were obtained from a series of laboratory tests conducted on the Sebit-25 to determine error probability vs noise, level changes, delay distortion, carrier frequency shift, and line filter variations.

An Experimental Equipment to Reduce Teleprinter Errors in the Presence of Multipath—James L. Hollis (p. 185)

Multipath propagation between radio terminals employing binary signalling elements produces a catastrophic rise in teleprinter error rate when the difference in path delay time becomes appreciable compared to the duration of a bit. A commonly used four-channel multiplex system has a bit length of 6.7 milliseconds and is thus seriously affected by differences in path delay greater than approximately 3 milliseconds.

This paper describes a method of preventing the rise in errors when multipath propagation is present, by synchronously shifting the frequency of the transmitter and receiver following transmission of each bit. The receiver is thus responsive to the signalling element propagated by the shortest path and rejects the long path signals by filter selectivity. Spectrum occupancy and receiver bandwidth considerations which determine the magnitude and number of frequency changes are discussed, and a practical system is described. The general features of equipment used in testing this device are illustrated and discussed.

The compatability of the anti-multipath equipment with existing equipment and the ability to reduce the error rate substantially, under conditions of ground-scatter multipath propagated by the *F* layer, have been successfully demonstrated.

Impulsing of Linear Networks in Integrated Data Systems—Gerald K. McAuliffe (p. 189)

Waveforms useful in data transmission may be obtained by impulsing suitable linear networks, and these same networks may be used, in certain cases, as receiving matched filters. A filter design for certain low-pass waveforms is described, together with a procedure for realizing band-pass analogs of these low-pass waveforms. The latter avoid the use of modulators. Practical results are described.

Angular Diversity Reception at 2290 MC Over a 188-Mile Path—J. H. Chisholm, *et al.* (p. 195)

Experiments were performed over the 188-mile Round Hill-Crawfords Hill path at 2290 mc to determine the feasibility of using angular diversity reception in a tropospheric scatter system. Using a 28-foot reflector, two beams were produced with two separate feed systems. The correlation of the signals received on one of the two beams with that received on the other was determined for various spacing of the beams, as well as for the azimuthal position of the antenna.

These experiments show that angular diversity techniques can be effective depending on the proper choice of frequency, antenna size, and beam separation for paths in the neighborhood of 200 miles in length. A substantial "diversity gain" can be achieved even though partial correlation exists. These results also appear to be in good agreement with theoretical predictions for equal means and for the short periods of time applicable to obtaining reliable voice and high speed teletype communications.

Real Time Data Transmission System—C. R. Scott and W. H. Butler (p. 201)

A real-time data transmission system was designed for and installed at the Atlantic Missile Range. This system is used to transmit the digital range, azimuth, and elevation coordinates from remotely located ANF/PS-16 radars into the Range Safety IBM 704 Computer at Cape Canaveral, Fla. The radar data is transmitted at a 10PPS rate and is used in the computation of a predicted impact point ten times a second within the computer. The predicted impact point is displayed on vertical plotting boards or use by the Range Safety Officer.

Tropospheric Scatter Path Loss Tests, Florida Bahamas—Kenneth P. Stiles (p. 205)

Telephone service between the United States and the Bahama Islands is now provided by means of high-frequency radio systems working in the 2–7 mc range. To handle properly the large volume of traffic during the peak winter season requires that more than the present nine circuits be provided. The lack of available frequencies in the 2–7 mc range, together with the comparatively poorer grade of facility obtained from these radio systems, makes it desirable to investigate other methods of providing telephone facilities. The fact that the present Miami-Havana tropospheric scatter system is performing so well, and that the distance from Miami to Nassau is the same as that to the Cuban terminal, made this type of system very attractive. At the time the Cuban system was being developed, klystron tubes capable of high outputs above 1000 mc were not available. For this reason, the Cuban system was designed to operate in the 700–900 mc range. Since that time tubes capable of high output levels at frequenices above 2000 mc have been developed and it was considered desirable to operate at these higher frequencies rather than in the lower.

Applicability of Multipath Protection to Meteor Burst Communications—T. G. Knight (p. 209)

This paper investigates past methods of improving the duty cycle of meteor scatter communications links in the presence of multipath distortion and suggests using a technique, for further improvement, which has proved useful at HF frequencies. It notes also, that use of this technique in conjunction with improved end-of-message error detection techniques should yield an improved duty cycle for meteor burst communications.

A Formalized Procedure for the Prediction Analysis of Multichannel Tropospheric Scatter Circuits—Charles A. Parry (p. 211)

In order to evaluate the potentialities of the scatter link and to minimize the financial risk involved in its implementation, examination of many combinations of path, sites, and system configurations is desirable. To assist this process, and to minimize the financial risks involved in uncertainties, a formal analytical procedure for the study of these circuits is desirable. The essential structure for such a procedure is outlined. A step-by-step process is involved, commencing with determination of an objective weighting factor for site evaluation. Data are presented for resolution of further steps dealing with median path loss, design accuracy, traffic loading, instantaneous fading, SNR, error rates, bandwidth and power. A performance index for path evaluation is used so that an optimum path-site combination may be selected. An index for comparison of various paths carrying different traffic leads with different reliabilities is suggested. Equations for use of this data in specific design situations are also given.

Contributors (p. 222)

Electron Devices

VOL. ED-6, NO. 3, JULY, 1959

Electron Beams in Axially-Symmetric Crossed Fields—John A. Bradshaw (p. 257)

M-type traveling-wave tubes use electron beams that drift in crossed electric and magnetic fields. One such tube, the axiotron described by Warnecke and Doehler in 1950, used a hollow beam drifting parallel to the tube axis in a radial electric field crossed by an aximuthal magnetic field. The addition of an axial magnetic field to the azimuthal one adds another degree of complication and flexibility to the beam equations, yet maintains their symmetry

about the tube axis. It gives, in effect, a helical magnetic field crossed by a radial electric field.

This report examines the behavior of hollow electron beams drifting in laminar flow through fields of the latter configuration. It defines a stability index for electron paths, and four fairly general types of beam. It determines the stability index and the distribution of space charge obtainable in each type as functions of the amplitudes and directions of the fields and drift velocities. In general, the density tends to be greatest at the inner beam radius, but it is possible to approach uniform density in stable beams.

This report does not consider beam launching nor the "gun" problem; nor does it consider over-all beam instabilities such as scalloping.

Laminar Flow in Magnetically-Focused Cylindrical Electron Beams—James L. Palmer (p. 262)

The behavior of a cylindrical electron beam in a magnetic field is discussed in terms of a laminar-flow model. By numerical integration of the equations of motion, the maximum and minimum radii of excursion and the wavelength of the undulations for each electron are presented in graphical form for various boundary conditions on the electron beam. By the proper selection of the boundary conditions, *e.g.*, magnetic field strength at the cathode, the graphs are utilized to describe Brillouin flow, space-charge-balanced flow, immersed flow, confined flow, and, in fact, any electron flow which satisfies the laminar flow criterion. The perturbations introduced by improper injection conditions for any of the flows mentioned can be read directly from the graphs. A study of the wavelength and the amplitude of such perturbations as a function of radial position in the beam determines if a given type of flow with given injection conditions satisfies the laminar flow criterion. The sensitivity of the various types of electron flow to misadjustments of the boundary conditions is clearly revealed by the graphs; *e.g.*, the amplitude of the undulations in Brillouin flow is very sensitive to the adjustment of the magnetic field strength whereas, for immersed flow, a similar deviation in magnetic field strength has very little effect on the amplitude of the undulations.

Point-Contact Diodes in Terms of *p-n* Junction Theory—Robert E. Nelson (p. 270)

A "*formed*" *n*-type germanium point-contact diode is qualitatively reminiscent of an idealized model that comprises an abrupt hemispherical *p-n* junction, both regions of which may have moderate resistivity, terminated on the inner (*p*) and outer (*n*) sides by hemispherical ohmic contacts. The extent to which this model can be justified quantitatively is investigated. Low-injection analyses of the static and small-signal, frequency-dependent properties suggest that the model is capable of predicting the corresponding experimentally-observed behavior. Consideration of space-charge-layer widening with reverse bias allows the computation of breakdown and punch-through voltages, which correspond in magnitude range to the observed peak inverse voltages of formed germanium point contacts. A high-injection analysis of the static forward characteristic indicates approximate agreement between theory and experiment, even for the nonlinear spreading resistance.

The Nesistor—A Semiconductor Negative Resistance Device—Robert E. Nelson (p. 278)

A semiconductor device similar in principle to the injecting-drain-field-effect transistor, having wide ranges of controllable negative resistance which can be used in counting, flip-flop, amplifying, and oscillator circuits, is described. The negative resistance arises from the modulation of the current between two ohmic contacts of circular symmetry, on a flat semiconductor wafer, by the effect of the collection of minority carriers on the pinching potential of a collector electrode. Families of negative resistance, of either the shunt or series type, are obtainable depending upon the mode of operation. Power gains of 60 and thermal dissipation of 1/4 watt have been achieved in liquid cooled units the size of high-frequency transistors. An improved sandwich-type base tab for mounting semiconductor wafers is shown. A theoretical analysis of the operation of the device permits prediction of the effect of various physical parameters upon the static electrical characteristics.

Super-Radiation and Super-Regeneration—C. Greifinger and G. Birnbaum (p. 288)

The transient behavior of a two-level spin system coupled to an electric circuit is investigated by using the equations of Bloembergen and Pound. The equations are solved, in the limit where the circuit ringing time is very short compared with all other characteristic times, for two cases: 1) the spin-lattice and spin-spin relaxation times both infinite, with an externally applied driving field, and 2) the spin-lattice relaxation time infinite but the spin-spin relaxation time finite, in the absence of an external field. In case 1), it is shown that the motion of an initially inverted magnetization under the action of an applied signal consists roughly of two stages: in the first stage, the effect of radiation damping is unimportant and the motion of the system is determined principally by the applied signal via the ordinary Bloch equations, whereas in the second stage, the motion is essentially the same as if the applied signal had been turned off and only radiation damping were present. In case 2), it is shown that a delayed peak in the emitted radiation should be observed under certain conditions. The delayed peak condition is identical with that derived by Bloom. Curves are presented showing the peak power and the time at which the delayed peak occurs as functions of the relevant parameters. In connection with the ordinary maser behavior of a two-level spin system, it is shown that for values of the parameters typical of steady-state maser amplification, the effects of radiation damping should be unimportant. Finally, systems are examined for which the radiation damping time is much shorter than all other characteristic times (super-regenerative systems). It is indicated how such systems might be operated as one-shot multivibrators or as linear amplifiers. For the latter type of operation, an expression for the gain is derived which is found to be similar to that encountered in ordinary circuit theory.

A Low Potential Collector Employing an Asymmetrical Electrode in an Axially-Symmetric Magnetic Field—D. A. Dunn, *et al.* (p. 294)

A collector for a beam-type tube with an axial magnetic focusing field can be made to operate at a potential near cathode potential without returning secondary electrons, if the beam is deflected and caused to pass an asymmetrical electrode properly positioned in the axially symmetric magnetic focusing field. Collection takes place in a region of radial electric field. Experimental results on such a device indicate successful operation, provided the velocity spread in the beam is not too large.

Electrostatic Optics for Camera Tubes—R. W. Redington (p. 297)

Two versions of an electrostatic focusing and deflection system suitable for camera tube applications are described. Focusing properties, resolution and aberrations are discussed.

Thermally-Induced Cracking in the Fabrication of Semiconductor Devices—Theodore C. Taylor (p. 299)

The literature bearing on the cracking of semiconductor devices due to thermally induced strains is reviewed. A model is developed to describe in qualitative terms, the stress distribution and mechanics of cracking and the significant variables of the cracking process are summarized. The remedial measures which have been proposed as solutions to the cracking problem are discussed. An analytical model is given which describes the stress distribution in the chip of a semiconductor device, and predicts a location of maximum stress which is in agreement with experimental results. A formula is derived for the calculation of the maximum semiconductor tensile stress in an elastic model. The modifications requires of the model in cases of inelastic behavior are discussed.

Three appendixes are given to present: 1) experimental methods of crack detection, 2) analytical design methods for tabbed device structures, and 3) references for some structural properties of germanium and silicon.

Medium Power High-Speed Germanium Alloy Transistors—H. E. Hughes, *et al.* (p. 311)

A complementary pair of medium-power high-speed switching transistors was required to satisfy the needs of an electronic switching system. Units have been designed and produced which exhibit a median cutoff frequency of 7 mc and a punch-through voltage of 70 volts.

High yields have been achieved on established production lines by very close manufacturing controls of the critical alloying variables, namely, germanium wafer thickness, alloyed junction area, concentricity, mass of alloying material, alloying temperature, and special material properties such as orientation and etch-pit density.

A vacuum-tight transistor structure has been designed to permit the dissipation of one-half watt of power at 25°C in free air. The structure embodies an all-copper cold-welded encapsulation for efficient heat removal. Important techniques concerning the cold-welding process will be discussed, and the particular die contour used will be illustrated in some detail. Additional cleanliness advantages are obtained by the use of the cold welded seal.

New Methods for the Measurement of Cathode Interface Impedance—H. B. Frost (p. 315)

Two improved methods for the measurement of cathode interface impedance have been developed, and their limitations have been analyzed. One of these, the complementary network method, is an improvement of a technique disclosed at the IRE National Convention in 1952. The other, the shunt admittance bridge, has not been described previously. Both methods allow the measurement of impedance with both small resistance and short time constant, well below the limit, 50 ohms at 0.1 μsec, of most present equipments. With the development of improved cathode alloys, the measurement of interface impedances having short time constants and low resistances has become important to control this parameter in manufacture and to obtain further improvement.

For the complementary-network bridge, the theoretical analysis has shown the extreme importance of minimizing stray inductance in the complementary network. When corrections are applied, the complementary-network bridge has good accuracy, with less than one-ohm error at 10 ohms and 0.05 μsec and lower relative errors for higher resistances.

The shunt admittance bridge is most satisfactory when tubes with transconductances greater than 10,000 μmho are to be measured. An impedance transformation is used which allows much easier physical realization of the measurement network than in other interface measurement methods. For tubes with transconductances greater than 10,000 μmho, the shunt admittance bridge will provide accurate time constant and resistance data down to 0.02 μsec and 5 ohms.

Maximum Rapidly-Switchable Power Density in Junction Triodes—J. M. Early (p. 322)

The maximum power density which may be switched at (switching time/current gain) quotients comparable to $1/2\pi f_\alpha$ is shown to be $10^5-4\times10^5$ watts/cm^{2}for p-n-p germanium transistors. This result is derived first for junction triodes in which the collector depletion layer at peak reverse voltage lies largely in a collector body of conductivity type opposite to that of the base; *e.g.*, diffused base transistors of the mesa type. The limitation arises from the linear dependence of maximum (scattering limited) current density (J_{max}) on collector-body impurity concentration (N_{Ac}) and from the approximately reciprocal dependence of breakdown voltage (BV_{CB}) on the same parameter.

It is shown that space-charge limitation of current density leads to a somewhat lower limit for intrinsic collector barriers of the same maximum width and, *a fortiori*, to a lower value for collector barriers lying largely in material of the same conductivity type as the base layer. Similar limits for n-p-n germanium and for silicon transistors are higher but generally comparable.

On the Periodic Coupling of Propagating Structures—Nathan Rynn (p. 325)

An analysis of two propagating structures periodically coupled together, based on a method developed by J. R. Pierce, is presented. A periodic structure that supports a backward wave may be coupled to a structure that supports a forward wave by coupling to alternate cells of the former. The coupling is completely analogous to the case of continuously coupled waves, *i.e.*, energy is transferred back and forth between the two guides periodically and the period of the transfer is inversely proportional to the strength of the coupling. The period of the transfer is also a function of the number of couplers per unit length. A method of measuring the coupling coefficient is presented and application to a coupled-structure attenuator is discussed.

The Effects of Electrode Resistance in Electroluminescent Cells—Henry F. Ivey (p 335)

The effects of electrode resistance on the voltage drop, the power dissipation, and the equivalent circuit constants of electroluminescent cells have been calculated by means of linear transmission line theory. In practice, electroluminescent cells have nonlinear characteristics which make the actual problem very difficult to solve. It is believed, however, that the present considerations serve to give a qualitative picture of the effects of electrode resistance in actual cells.

Semiconductor Diode Amplifiers and Pulse Modulators—W. Ko and F. E. Brammer (p. 341)

The reverse recovery characteristic of a semiconductor diode depends not only on the crystal properties and the physical dimensions of the diode but also on the circuit in which it is used. The effects of the circuit parameters, namely, forward current, reverse voltage and reverse loop impedance, on the diode recovery characteristics were studied experimentally on germanium and silicon junction diodes. The results are given in curves which illustrate the relationships between these circuit parameters and the maximum reverse current, as well as the constant current duration. Based on these curves, circuit applications were developed. The experiments on a pulse amplifier performed by the National Bureau of Standards, were repeated. The results showed a maximum power gain of 22 db per stage. Four pulse modulator circuits were designed. They are amplitude modulator, sampler, pulse duration and position modulators. Linearity and frequency response tests on these modulator circuits were conducted. The results indicated that they have small distortion and flat frequency response from dc up to several tens of kilocycles per second. Modifications of the pulse amplitude modulator provides amplifiers for continuously varying signals. Four such circuits are given.

A Design Theory for the High-Frequency p-n Junction Variable Capacitor—C. J. Spector (p. 347)

One of the more significant uses of the p-n junction variable capacitor is as an HF (>100 mc) tuning element. Structures which have been available have had rather low Q at these frequencies. In order to determine the limits imposed on Q by the physics of the device, a fundamental study has been made of the problems of the HF junction capacitor. Equations have been developed for the prediction of Q in alloyed and diffused structures. Optimization criteria are proposed which permit design of capacitors in which Q is no longer a significant limitation. In support of the theory, experimental results are presented on units designed and fabricated in accordance with the optimization criteria. Q's in excess of 500 have been observed at 100 mc.

The Radio-Frequency Current Distribution in Brillouin Flow—M. Chodorow and L. T. Zitelli (p. 352)

It has been shown that in an electron beam with Brillouin focusing, two pairs of space-charge waves are possible. One pair has the peculiar property of having no RF charge density in the volume of the beam, with most of the current being caused by ripples of the boundary. This paper shows that, in the case of modulation by the gridless gap of a klystron, it is only these space-charge waves which are excited in the electron beam. This result has also been verified elsewhere by experiment. In addition to the detailed calculation, a simple proof is given which demonstrates why one gets the particular behavior predicted by the detailed theory, namely, a modulated beam with no RF charge density in the volume. This effect arises from the fact that the modulation is produced by an electric field with zero divergence, and therefore the RF velocity produced also has zero divergence. Zero divergence of the velocity is the condition for an incompressible fluid; *i.e.*, constant density. In the case of modulation by a grid, the electric field does not have zero divergence and this kind of behavior does not occur.

Experimental Notes and Techniques

Technique for Making Crack-Free Alloyed Junctions in Silicon—Theodore C. Taylor (p. 358)

Contributors (p. 360)

Engineering Management

Vol. EM-6, No. 3, September, 1959

A Profitability Criterion for Measurement and Decision-Making—John C. Fisher (p. 65)

Consideration of the legal structure of corporations, and of long-term price and dividend trends of industrial stocks, leads to the conclusion that a corporation achieves its maximum profitability when the discounted value of the over-all flow of cash associated with its various activities is a maximum. The appropriate discount rate is somewhere near 6 per cent. Since each project, individually, must have its maximum possible discounted value, the profitability criterion serves as a criterion for decision-making.

Production Selction—Witchraft or Wisdom—Charles S. Roberts (p. 68)

This paper develops the thesis that marketing research can make a significant contribution to new product conception and development. A discussion of new product development is presented within the framework of meeting the challenge of changing needs of the market and the competition of companies who are market-oriented and working to anticipate the needs of their customers. Companies engaged in research and development work are committing important resources in new product and new concept development in order to survive, yet there is a risk of failure that is inherent in such activities. Although it is agreed that the risk of failure cannot be eliminated, it is recommended that this risk can be reduced by utilizing the discipline of marketing research.

Group Contracting—James D. McLean (p. 71)

The pattern of military electronics procurement in recent years has shifted away from large-scale production of relatively simple systems—black boxes, they may be called—and toward the development and production of fewer systems of increasing complexity. To meet the challenges imposed by this change, the industry has found it necessary, in many cases, to form teams of specialist organizations, each possessing one or more of the capabilities necessary for the task in question.

Although the structure of the relationships which bind the team together may vary, the basic attributes are the same. In this paper, the characteristics of team contracting are revealed and the advantages of this form of solving specific military problems are discussed.

The Management of Research and Development—Abraham Katz (p. 75).

Our intensive search for knowledge, basic and applied, must be accompanied by a corresponding search for the principles underlying the management of research and development. An attempt has been made here to seek out the factors of major importance and to organize them into a meaningful whole. Basic to this analysis have been the views of product value and cost as streams in time, and of managerial capabilities as probabilities of project completion, also varying in time. A simple model based on these concepts has been developed for a business in which the products are characterized by great complexity and by rapid change. The model is simply a tool to understanding—a way of looking at a business. Rational procedures have been derived for making certain of the major project decisions.

Management Control of Professional Operations—Actuality or Illusion?—P. S. Schmidt (p. 81)

Whether management has effective control of professional operations such as Research and Development is difficult to judge because the required level of creativity varies from project to project. To eliminate this variable, patent operations, which require specialized creativity of constant intensity, were chosen for study. Results of a questionnaire sent to 100 electronics companies indicate that quantity, quality and cost controls in most corporate patent programs are rudimentary or nonexistent. This raises a question as to whether management control (in the cybernetic sense) is achievable in any area of professional operations.

Magazine Review Section (p. 87)

For Your Bookshelf (p. 89)

Information Theory

Vol. IT-5, No. 3, September, 1959

Frontispiece (p. 96)

Guest Editorial—D. Gabor (p. 97)

Note on Unique Decipherability—E. T. Jaynes (p. 98)

We consider an alphabet of a letters, used under the restrictions: 1) messages uniquely decipherable into words by use of one of the

letters as a space mark, and 2) words limited to a maximum length of L letters. Although imposing these constraints simultaneously may cause a large reduction in the channel capacity of the alphabet, neither by itself causes any reduction. Accordingly, in the absence of constraints other than 1), an inequality of McMillan pertaining to uniquely decipherable messages can be made to be an equality.

Defining "semi-optimal" transmission by the condition that the mean transmission time per word is minimized for a given entropy per word, we find the attainable rate of information transmission under semi-optimal conditions. Transmission at full channel capacity is a special case of semi-optimal transmission. Some generalizations and analogies to statistical mechanics are discussed.

On the Use of Laguerre Polynomials in Treating the Envelope and Phase Components of Narrow-Band Gaussian Noise—Irving S. Reed (p. 102)

The joint probability density of the envelope of a Gaussian process at two different times is expanded by the use of Hardy's identity into a series involving Laguerre polynomials. It is shown how this result may be used to estimate the cross-correlation function of the output of two quite general envelope-distorting filters. A generalization of this result, involving the use of the associated Laguerre polynomials, is obtained and applied to the calculation of a cross-correlation function which involves both the phase and envelope of the process at two points in time.

Interchannel Correlation in a Bank of Parallel Filters—Janis Galejs and William M. Cowan (p. 106)

The first-order effects of interchannel noise correlation on the false alarm and incorrect dismissal probabilities are computed for a bank of parallel RLC filters by expanding the envelope distribution of the n filter outputs in a power series.

The correction to the false alarm probability due to noise correlation is found to decrease with increasing threshold-to-rms-noise ratios. If the filter-separation-to-filter-band width ratios are larger than 0.2, it is less than 15 and 0.2 per cent for threshold-to-rms-noise ratios exceeding 12 and 14 db respectively.

The correction to the incorrect dismissal probability, which is computed by considering the signal output of three contiguous filters, increases with increasing threshold-to-rms-noise and signal-to-threshold ratios. Even for filter separations larger than the filter bandwidth, it may be in excess of 100 per cent if the threshold-to-rms-noise ratio exceeds 12 db and the signal-to-threshold ratio is larger than 1.2.

Application of Modular Sequential Circuits to Single Error-Correcting p-nary Codes—Thomas E. Stern and Bernard Friedland (p. 114)

Some Spectral Properties of Weighted Random Noise—H. S. Shapiro and R. A. Silverman (p. 123)

We studied the power spectrum and, more generally, the spectral covariance of weighted stationary processes. It is found that if the power spectrum of the underlying stationary process is suitably well behaved and properly matched to the weight function, then the high-frequency behavior of the power spectrum and spectral covariance is especially simple. Asymptotic theorems describing this behavior precisely are given.

Extremal Coding for Speech Transmission—Max V. Mathews (p. 129)

A digital coding and its application to speech transmission is described. The coder determines the amplitudes and times of successive extremes (relative maxima and minima) of the signal. This information is decoded at the receiver by interpolating a function between extremes so as to connect them smoothly and preserve the extremes of the original signal in the reconstructed wave. Thus, the coding is a nonlinear sampling technique. It is related to clipped speech encoding which effectively transmits only the times of the extremes.

The properties of the coding for speech signals have been studied by digital simulation on an IBM 704 computer. Information rate, statistics of the extremes data, and quality of the resulting signal have been evaluated. The buffer size necessary to receive the randomly ocurring data and transmit at a constant rate was measured.

Correspondence (p. 136)
Contributors (p. 144)

Medical Electronics

Vol. ME-6, No. 3, September, 1959

A Multichannel Analyzer for Heart Potentials—C. V. Nelson, *et al.* (p. 107)

Computers Applied to Ballistocardiography—S. A. Talbot (p. 109)

A New System for Electrocardiographic Recording, Analysis, and Diagnosis—J. Martinek, *et al.* (p. 112)

A Study of the Advantages of Displaying the Heart's Electrical Activity as Linear Time-Scale Curves of Spacial Magnitude and Orientation—J. A. Abildskov, *et al.* (p. 116)

An Automatic Pressure Regulator for Extracorporeal Circulation—O. Z. Roy (p. 118)

An automatic pressure regulator for controlling venous pressure during extracorporeal heart operations is described. The controller is used in procedures where a pressure is maintained in the venae cavae; *i.e.*, where gravity flow is not used to drain the venous blood.

A differential pressure transducer produces an error signal which controls the field current in a dc shunt motor and, consequently, the rate of pumping. The sensitivity of the controller can be varied in eight steps; on the most sensitive range, an error of less than 0.20 mm Hg can be detected and corrected. The total change in motor speed and hence pumping rate is ± 20 per cent.

The Computation of Muscle Activity from the Integrated Electromyogram—B. R. Fink and M. L. Scheiner (p. 121)

The integration of a signal of varying pulse amplitude and frequency is discussed. Several solutions are considered, and a method is described in which an accurate integration is obtained with a circuit of short time constant and virtually infinite decay time.

Automatic Reading and Recording of Digital Data in the Analysis of Primate Behavior—D. McConnell (p. 123)

The Human Being as a Link in an Automatic Control System—Part I—T. J. Higgins and D. B. Holland (p. 127)

Adaptive Servomechanisms—Charles W. Johnson (p. 136)

A discussion is given on some of the current ideas behind the control engineer's approach to the problem of developing servomechanisms which exhibit some degree of adaptive behavior. Several categories of adaptive systems are discussed and an attempt is made to associate the operating principle of the systems in each category with the behavior of the human being when he acts as a controlling device. A particular system developed for application in the field of automatic flight control is discussed from a functional point of view. The controller, using an analog model which operates on the input information, determines a "standard of performance" for the controlled element which closely approximates the performance desired by an experienced operator. The remainder of the controller, using a very simple passive network as a switching function computer to determine the state of a bistable device, forces the controlled element to operate in such a manner as to minimize continuously the error between the desired performance and the actual performance. The controller exhibits adaptive behavior in the sense that it operates in such a manner as to keep the actual performance of the system practically invariant, although the parameters of the controlled element change over a relatively wide range of values.

The Ultraviolet Flying-Spot Television Microscope—P. O'B. Montgomery and W. A. Bonner (p. 143)

Transmission of Ultrasound Through Living Human Thorax—H. D. Crawford, *et al.* (p. 146)

Experiments are described demonstrating the passage of one-mc/sec continuous wave ultrasound through the heart and lungs at power levels of 100 mw/cm² at the tranducer terminals (a total of 1.25 watts). When the sound was directed through the region of the heart, the ultrasound was modulated by the moving intra-thoracic structures in synchonism with the heart beat. The records obtained were modified both by exercise and by amyl nitrite administered to the subject, but remained synchronous with the heart rate. Modulation of the ultrasound did not occur in two warm corpses. Sonic energy at the levels used to traverse the thorax did not affect a simultaneously recorded electrocardiogram. No deleterious effects have been observed on a subject whose heart was irradiated at 1 watt/cm² and 3 watts/cm² (totals of 12.5 and 37.5 watts, respectively) applied to transducer terminals at intervals over a period of one year (Appendix I). When continuous wave ultrasound was directed through a lung field clear of the heart, it was found that the attenuation varied 50 db between full inspiration and a lung emptying of 3400 cubic cm (0 db = full inspiration). In addition to direct transmission, sound is scattered throughout the thorax. The mechanics of the ultrasonic phenomena are described.

Problems in Electroencephalograph Analysis—M. G. Saunders (p. 152)

The Analysis of Electroencephalograms by the Use of a Cross-Spectrum Analyzer—Ezra S. Krendel (p. 154)

An Automatic Digital Recorder for Timing Sequential Events—Stanley M. Block (p. 162)

A Method of Measuring the Dynamic Characteristics of Muscle Rigidity, Strength, and Tremor in the Upper Extremity—David D. Webster (p. 164)

Computational Aspects of Brain Function—Reginald G. Bickford (p. 169)

Digital Recording of Electrocardiographic Data for Analysis by a Digital Computer—L. Taback, *et al.* (p. 172)

A corrected orthogonal 3-lead system has been used to record electrocardiograms directly from patients at Veterans Hospitals, using three FM channels of magnetic tape. A pilot facility has been designed and assembled by NBS to permit a medical technician to inspect these on an oscilloscope and select a significant cardiac cycle. This is automatically sampled at millisecond intervals and the numerical values are stored in digital form on magnetic tape acceptable to an electronic computer. Upon writing various programs for the digital computer, the cardiac researcher will have a flexible tool for objective analysis of large quantities of biological data by a variety of possible criteria.

Possible Approaches to Multiple-Channel Tape Recording for Biomedical Purposes—D. H. Smith, *et al.* (p. 176)

A Statistical Study of the Effects of Electric Fields on the Movements of Mammalian Sperm Cells—John W. Trank (p. 179)

A micro technique has been developed to facilitate the study of electric field effects on the swimming pattern of sperm cells. The in-

strumentation for this technique, a microelectrophoresis vessel, a metering motion picture projector, and a simple analog computer for data handling, are briefly described. It is shown experimentally that 1) an electric field imposed on a cell suspension acts primarily to direct the cells to the anode without appreciably changing their swimming speed, and 2) the field effects are not linear functions of field strength. It is postulated that the field effect is primarily galvanotaxis and that the cells seek a position of minimum stimulation and therefore must have a transverse sensitivity axis.

Autocorrelation and Cross Correlation Analysis in Electroencephalography—John S. Barlow (p. 184)

Autocorrelation and cross correlation analysis, which have been used extensively in statistical communication theory in the past few years, can be applied, with certain limitations, to the study of the EEG (electroencephalograph). Autocorrelograms for normal subjects can be classified in several categories, according to the dominant frequency, or frequencies, present, and other parameters. Cross correlograms of EEG recordings from different locations on the head permit a comparison of the electrical activity at the two locations. Correlation functions and power-density spectra contain equivalent information because the one may be obtained from the other by Fourier transformation; but, because of the squaring and multiplication that appear in the computation process, the data so obtained are not exact equivalents of the frequency spectra derived from tuned resonators. A special case of cross correlation analysis (cross correlation of a repetitive signal with a synchronously occurring brief pulse) can be applied to the detection of electric responses evoked by sensory stimulation. This process is equivalent to averaging a large number of individual responses. Illustrative examples, obtained from semi-automatic computers especially designed for the purpose, are given.

PGME Applications for Affiliates (p. 189)

Military Electronics

Vol. MIL-3, No. 4, October, 1959

Frontispiece (p. 127)

Guest Editorial—Bernard A. Schriever (p. 128)

Scientific Objectives of the Able-3 Program—Applied Physics Dept., Space Technology Labs., Inc. (p. 129)

The purpose of the Able-3 program is to place a scientific observatory in a highly elliptic satellite orbit. A scintillation counter, ion chamber, Geiger counter, and proportional counter telescope in the payload permit comprehensive mapping of corpuscular radiation over a large volume of the geomagnetic region, including the Van Allen radiation belts. Simultaneously, the fundamental static quantities, electron density, and vector magnetic intensity are to be measured. A VLF experiment is included to measure upper atmosphere VLF noise and to study the propagation characteristic of VLF between the ground and the satellite. A radio scintillation experiment using radio telescopes will measure the effects of ionospheric irregularities on amplitude and phase. Micrometeorite detection equipment in the payload provides a two-point momentum spectrum of micrometeorites encountered, and an image scanner is included to examine reflection characteristics of the earth.

Able-3 Payload Design—John E. Taber (p. 143)

This paper discusses the Able-3 payload instrumentation. The design parameters and functional characteristics of this instrumentation are discussed in terms of the two goals of this program: to build a payload which gathers as much scientific information as possible concerning the space environment about the earth, and to develop and check out communications, power supply, and temperature control systems suitable for subsequent interplanetary space probes. The basic electronics of the satellite and their relationship with the experimental equipment as well as with structural and other aspects of the satellite are discussed in some detail. Particular emphasis is placed on the communications system, and, in particular, on the new digital telemetry system and its value to deep space exploration.

Three-Dimensional Interplanetary Trajectories—A. B. Mickelwait, *et al.* (p. 149)

Developments in guided missiles and related scientific areas have reached a state where ballistic flights to the planets Venus and Mars are feasible and imminent with existing hardware. This paper discusses considerations involved in making an actual ballistic flight to Venus. Conventional two-dimensional analysis is compared to the actual three-dimensional case. Burn-out conditions required to minimize the problems of guidance, payload, range safety booster aerodynamics, midcourse guidance, and capture are established. Problems relating to launch times, launch latitude, and interplanetary communications are also discussed.

Detection and Evaluation of Space Radiations—dePaul T. Corkhill and R. A. Hoffman (p. 162)

In the very near future man will escape from his terrestrial environment and venture into space. The first flights will be limited space voyages circling the earth only one or several times at altitudes from 100 to 500 miles. As technological advances permit, these space journeys will become longer in duration and farther from earth until travel between planets in our solar system is accomplished. Ultimately of course, travel outside our solar system is envisioned.

The hazards of space flight are numerous. An environment paralleling that of the earth's must be simulated as closely as possible inside the space capsule. In providing such an environment, those problems of air regeneration, temperature control, pressure control, etc., are overcome. One potential hazard from which man in space cannot be effectively protected is radiation. Therefore, the intensity of space radiations and their biological effects must be evaluated prior to prolonged space journeys if such journeys are to be accomplished without undue risk.

The aeromedical field laboratory is now studying a space radiation detection system which would be capable of detecting and identifying the several forms of space radiation and the intensity of each form. Once the types and intensities of radiation prevalent in space are ascertained, it will be possible to study, in earth laboratories, the biological effects of most of these radiations. Radiobiological studies should lead to realistic RBE (relative biological effectiveness) values for these radiations, and thus biological dose rates (rem/hr) can be established.

A radiation survey system such as described will be a very intricate electronic assembly. The biological studies to determine RBE values will require careful study. The unit must be compact, rugged, and lightweight if it is to be adaptable to satellite flights.

Presently, a feasibility study is underway to determine the most practical and efficient electronic assembly. Then follows the fabrication of the complete detection system. Orbital flights of this system must then be made to evaluate the types and intensities of space radiations. Biological studies of these radiations must then be made so that biological dose rates may be established. Once the biological studies have been completed, the RBE factors can be incorporated in the radiation detection system, *i.e.*, a system which will be capable of giving the space passenger a biological dose rate in rem/hr on a dial type instrument as well as his total accumulated radiation dosage during the flight. Admittedly, such a system may not be a prerequisite for the first toddling steps of man into space, but it must certainly form an integral part of future space vehicles when bolder journeys farther from earth are made.

High-Accuracy Electronic Tracking of Space Vehicles—P. F. von Handel and F. Hoehndorf (p. 162)

It is the purpose of this paper to show that optical accuracies can be reached with electronic tracking if the refractive index is known at the site of the radar, as well as at the site of the target. This is the case in tracking space vehicles with microwaves. The index can be measured at the tracking site and it is unity beyond the denser atmosphere. Ionospheric influences can be neglected in the higher kilomegacycle range. It is also shown that the uncertainty of the course of any particular profile between the surface of the earth and the target has only minute effects on range and angular errors. Accuracy limits are determined and presented numerically. The inherent high precision of modern electronic tracking systems can be fully utilized under these conditions; this is not the case in tracking vehicles flying in the atmosphere.

Some Reliability Aspects of Weapon and Other Space Systems Using Ballistic Missile Boosters—Henry Triwush (p. 173)

This paper shows that there is a need to differentiate, at least on occasion, between weapon and nonweapon space systems where their reliability is concerned. Three criteria are offered as a means of determining whether this differentiation need be made in the case of any particular nonweapon space system. Where this differentiation should be made, possible reliability approaches for the nonweapon space system are suggested.

Radar Beacons for IRBM/ICBM—F. J. Clark (p. 175)

This paper summarizes problems which confront engineers who are responsible for the design of radar beacons and beacon antennas used in IRBM and ICBM test vehicles. The most important factors which affect compatibility between the beacon and tracking radars at the test range are enumerated. Cited also are several design areas which should be correlated with the test range prior to finalization of beacon design criteria.

Design Studies for a Rubidium Gas Cell Frequency Standard—J. M. Andres, *et al.* (p. 178)

A description is given of several studies undertaken in the design of a small, gas cell stabilized atomic frequency standard making use of the field-independent hyperfine resonance of rubidium 87 at 6834 mc. In the standard considered, light from a rubidium vapor lamp is used to enhance the population differences between the atomic levels involved in the resonance and also to provide a means of detecting the microwave resonance. One of the studies described is concerend with the generation of requisite microwave energy at the resonant frequency, another with the choice of an optimum length for the gas cell, and the last with the optimization of parameters for the modulation process used.

Some Considerations in the Design of the Guidance and Control System for Discoverer—John J. Schmitt, Jr. (p. 184)

The limited number of flight tests to date has indicated that the Discoverer satellite will be a highly reliable and effective system from which the ARPA and the Air Force expect to gain valuable additional knowledge of outer space. The achievement of this high degree of reliability and effectiveness of the satellite means that each of its subsystems must, in fact,

be even more reliable and effective. The Discoverer guidance and control system is meeting their specifications because of the simplicity of the over-all design—simplicity for reliability with sufficient sophistication to accomplish its mission effectively.

The mission of the guidance system is that of providing adequate attitude, velocity, and time references to guide the satellite into a desired orbit, to control its attitude on orbit, and to provide switching in the proper sequence for certain principal satellite functions. The mission of the control system is simply that of positioning the vehicle in the proper attitude commanded by guidance. The investigations that were made and those which are being continued in the determination of the optimum configuration for the desired performance are described in some detail. The present system, consisting of an inertial reference device, a horizon scanner, and a computer for guidance, and of both pneumatic and hydraulic control systems, are discussed.

In summary, a typical flight of the Discoverer, from separation from the Thor booster until stabilization on orbit, is outlined and the functions of the guidance and control systems are described.

Contributors (p. 185)
Annual Index 1959 (follows p. 187)

Space Electronics and Telemetry

Vol. SET-5, No. 3, September, 1959

Communication Techniques for Space Exploration—Eberhardt Rechtin (p. 95)

This article was first given in a symposium at the California Institute of Technology on "Realities of Space Exploration," showing as graphically as possible that space communication is practical, that the extrapolation of the state of the art is straight forward, and that the real limitations are those of: 1) external noise, 2) handling an extreme volume of data, 3) certain relativistic effects (more distant future), 4) time, and 5) economics and money. These limitations, at present, indicate frequencies between 500 and 5000 mc, automatic data handling, an awareness that communications outside the solar system is presently impossible, an appreciation that time scales of many years are expected in development and flight times, and a surprising conclusion that space exploration will probably pay for itself.

Telemetered Parameters of Primates and Humans from Space Capsules—T. C. Helvey (p. 99)

A Circularly Polarized Feed for an Automatic Tracking Telemetry Antenna—R. C. Baker (p. 103)

Characteristics of a feed that utilizes a unique method to produce a conically scanning main beam are discussed. Model and full scale test data are included to make the feed operation more clearly understood.

Certain criteria such as gain, side lobe level, and polarization must be considered when designing a primary feed for a paraboloid reflector. Also, the automatic tracking requirement calls for some means of producing an error signal for given off-target angles.

The feed discussed is a circular waveguide excited by orthogonal probes fed 90° out of phase to produce circular polarization. The electrical phase center of the feed is shifted around the focal point of the 60-foot diameter paraboloid reflector by rotating a hemispherical tapered-dielectric prism at the aperture of the waveguide. A ground plane around the waveguide mouth controls the illumination taper across the paraboloid aperture to yield equal E and H plane secondary beamwidths.

The Dynamic Analysis of the Averaging Type FM Discriminator—I. Cederbaum and S. Rozenstein (p. 111)

The dynamic response of an averaging type FM discriminator to a general FM input is analyzed on the assumption that the zero crossing of the input signal initiates impulses which are applied to a low pass filter. The boundaries between which the output voltage of that filter is varying are evaluated. The faithful decoding may start after an initial settling-down period which is often found to be short compared with the actual period of the measurement.

In order to show the practical use of the result obtained, two examples are given which deal with a linear and a parabolic change of the frequency with time.

A High-Speed, Airborne Digital Data Acquisition System—S. Cogan and W. K. Hodder (p. 117)

This paper describes a transitorized airborne PCM/FM data acquisition system. The prototype version of this system has, in the past few months, been subjected to a flight evaluation program, and the final version is now in the process of assembly and test. The system is primarily digital; however, the technical areas of switching and amplification of low-level analog signals will be emphasized and system aspects will be discussed.

The airborne system is part of a larger system designed to provide an accurate and reliable means of collecting information from a large number of transducers during aircraft flight testing, and to transfer this information in the most efficient manner to a digital computer for final data reduction. The Airborne portion collects, stores, and transmits flight-test data in digital form to the ground control record station trailer which monitors the progress of the flight test. The recorded data is then carried to the computer station which organizes and controls the selection of data in a form compatible with the requirements of an IBM type 704 computer.

A System for Editing and Computer Entry of Flight Test Data—S. F. Higgins (p. 123)

This paper describes a system of data editing with provisions for computer entry of flight test data as acquired by an integrated digital data system. Also described are system concepts that must be dealt with in solving problems incident to these activities.

The computer station described is provided with editing control facilities that permit selection of the desired prime and commutated channels which are essential for data reduction. The editing facilities provide for the most economic use of computer and manpower effort and are so designed that they permit convenient access to all instrumented channels.

In addition, peripheral equipment is described as an aid in the editing process for examining the raw data in terms of analog, quick-look, and permanent record equipment.

The Use of a Fractional Bi-Stable Multivibrator Counter in the Design of an Automatic Discriminator Calibrator—M. W. Williard and G. F. Anderson (p. 131)

This paper discusses the approach used in the design of an automatic discriminator calibrator system. This design led to analysis of the use of bi-stable multibrators to obtain a fractional countdown of the output frequency of a crystal oscillator. The final counter waveform is filtered to extract only a sinusoidal component of the square wave from the counters. Some properties of fractional counters are discussed, including the use of a 382.5/1 counter in the calibrator system.

Analysis of Multiplex Error in FM/FM and PAM/FM/FM Telemetry—J. Schenck and W. F. Kennedy (p. 138)

The primary object of the work described in this paper is to establish and delineate a procedure for the calculation of certain errors associated with the performance of FM/FM and/or PAM/FM/FM multiplex telemetry systems. The errors considered are those that are produced in a channel of the multiplex resulting from arbitrary frequency and phase selective networks, and those resulting from the interference of adjacent channel sidebands with respect to an arbitrary channel center frequency separation. To find these errors, a straightforward spectral analysis and synthesis is developed for practical models of standard FM/FM and PAM/FM/FM systems. Expressions are obtained for the outputs of a multiplex for given inputs, and for nonlinear distortion and adjacent channel interference, in terms of the conventional parameters of such systems. This method of analysis is entirely quantitative, and an effort has been made to develop it from a definite theoretical basis.

Because the FM process is nonlinear, and since the purpose of this investigation has been the evaluation of system performance rather than analytical insight per se, automatic digital computation is contemplated throughout. Nevertheless, it has been found that the results of the work involved in 1) the justification of a system model, 2) the derivations of functions defining the operations of the components of the model, 3) programming the functions for numerical analysis, and finally 4) performing relatively economical experimental numerical adjustments of the model parameters, lead to a valuable physical appreciation of the system behavior with respect to prescribed conditions.

Nonlinear distortion present in the demodulated output of a subcarrier channel is produced by a band limiting filter or the band-selection filter. This distortion is determined by comparing the demodulated output signal with a known modulating input signal. The input may be sinusoidal, which is of interest in the specification of distortion in FM/FM, or rectangular, which simulates the modulation in PAM/FM/FM. The output signal is obtained by a numerical computation signal of the derivative of the phase of the recovered FM subcarrier. A derivation is given for this phase derivative through the representation of the recovered subcarrier signal by a phasor whose instantaneous length and angle have been modified with respect to time by interference, and by the amplitude and phase characteristics of the transmission networks. Graphic results are given for both sinusoidal and rectangular modulating signals, for a range of modulation indexes, and for band-pass filters of the Butterworth type having various bandwidths and rates of attenuation.

The criterion for error in PAM/FM/FM is a deviation of the average, over a predetermined interval of the pulse, from the average value which would have been measured on an undistorted pulse over that interval. Curves are presented showing the maximum permissible duration, for 0.1 per cent and 0.5 per cent, error, of this predetermined interval in terms of bandwidth and band edge attenuation. Error resulting from sinusoidal modulation is presented in terms of harmonic distortion. These distortion results are exact in that they involve no approximations based on assumptions such as quasi-stationary conditions or small phase variations.

Comments Relative to the Application of PCM to Aircraft Flight Testing—Robert S. Djorup (p. 148).

The pending widespread use planned for PCM telemetry has caused some confusion in the area of PCM or digital standards. It is the purpose of this paper to discuss proposed PCM standards on a realistic basis and to show by example the organization of an integrated digital flight test system using these standards. Consideration is given to the variety of testing applications and ultimate usage of digital flight test data.

Contributors (p. 153)

Abstracts and References

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research, London, England, and Published by Arrangement with that Department and the *Electronic and Radio Engineer*, incorporating *Wireless Engineer*, London, England

NOTE: The Institute of Radio Engineers does not have available copies of the publications mentioned in these papers, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications, not to the IRE.

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The Index to the Abstracts and References published in the PROC. IRE from February, 1958 through January, 1959 is published by the PROC. IRE, May, 1959, Part II. It is also published by *Electronic and Radio Engineer*, incorporating *Wireless Engineer*, and included in the March, 1959 issue of that journal. Included with the Index is a selected list of journals scanned for abstracting with publishers' addresses.

ACOUSTICS AND AUDIO FREQUENCIES

534.213-8:539.2 3536

Absorption of Compressional Waves in Solids from 100 to 1000 Mc/s—J. Lamb, M. Redwood and Z. Shteinshleifer. (*Phys. Rev. Lett.*, vol. 3, pp. 28–29; July 1, 1959.) Experimental data are given for dependence of the amplitude absorption coefficient on frequency for crystal quartz, fused silica, Ge and Si.

534.231:534.88 3537

Studies on the Near Fields of Monopole and Dipole Acoustic Sources—C. W. Horton and A. E. Sobey, Jr. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 1088–1099; December, 1958.) When an observer is not farther than one wavelength from an acoustic source, he can determine the distance to the source from measurements of the pressure and particle velocity of the medium. Expressions are developed which are exact in the case of a monopole source. Measurements made using a dipole source are described.

534.522.1 3538

Determination of the Form of Finite-Amplitude Ultrasonic Waves by Light Refraction—M. A. Breazeale, B. D. Cook and E. A. Hiedemann. (*Naturwiss.*, vol. 45, p. 537; November, 1958. In English.) The refraction method (see 1050, April, Breazeale and Hiedemann) has been perfected so that the phase relation between harmonic components can be determined.

534.7 3539

Signal Detection as a Function of Frequency Ensemble: Part 2—F. A. Veniar. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 1075–1078; December, 1958.) Further experimental investigation of the detection of a signal in noise as a function of signal ensemble size and frequency range. Part 1:1052, April.

534.75 3540

Detection of Multiple-Component Signals in Noise—D. M. Green. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 904–911; October, 1958.) Experimental results are analysed by comparison with three mathematical models; for predicting the detectibility of a complex signal the most acceptable is a statistical summation model in which it is assumed that two or more critical bands may be linearly combined.

534.75 3541

What is Masking?—W. P. Tanner, Jr. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 919–921; October, 1958.) Three experiments are described and analysed in terms of a conventional definition of masking and a masking index conforming to this definition.

534.75:621.391 3542

Definitions of d' and η as Psychophysical Measures—Tanner and Birdsall. (*See* 3854.)

534.78 3543

Prediction of Speech Intelligibility at High Noise Levels—J. M. Pickett and I. Pollack. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 955–963; October, 1958.) An extension of the work described in a previous paper (2286 of 1958) to cover a wide range of speech and noise spectra. To predict the deterioration in intelligibility at high noise levels, a correction based upon a change in the over-all speech/noise ratio is acceptable at moderate intelligibility levels but, at low levels, secondary corrections are necessary.

534.79 3544

On Psychological and Systematic Bases of Loudness—E. Zwicker. (*Akust. Beihefte*, no. 1, pp. 237–258; 1958.) Loudness measurements made using 1-kc tone and noise are discussed in relation to loudness level comparisons. A basic "loudness function" is defined and a graphical method of evaluating loudness is described.

534.844 3545

Apparatus for Automatic Evaluation of Successive Sound Reflections—W. Junius. (*Akust. Beihefte*, no. 1, pp. 266–272; 1958.) Details are given of an electronic apparatus for measuring the sound pressure of successive reflections and recording the number of reflections according to their intensity and delay time.

534.844 3546

Characteristics and Evaluation of Reverberation Curves—H. Kuttruff. (*Akust. Beihefte*, no. 1, pp. 273–280; 1958.) The initial slope of a reverberation curve is shown to be proportional to the weighted arithmetic mean of the damping factors of all the relevant natural vibrations.

534.845 3547

Experimental Investigations on the Sound Insulation of Cylinders—M. Heckl. (*Akust. Beihefte*, no. 1, pp. 259–265; 1958.) Two characteristic frequencies are defined relating to the sound insulation of hollow cylinders. Between these two frequencies marked transmission bands are observed in the case of narrow-band noise; with wide-band noise the sound insulation is largely independent of frequency.

534.845 3548

Reflections from Gradual-Transistion Sound Absorbers—N. B. Miller. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 967–973; October, 1958.) Reflections are treated theoretically by considering the propagation of compressional waves in stratified media, and results are compared with experimental data obtained from structures suitable for use underwater.

534.845 3549

On the Relation between the Reverberant Sound Absorption Coefficient and the Normal-Incidence Absorption Coefficient of Fibrous Materials—M. Koyasu. (*J. Acoust. Soc., Amer.*, vol. 30, pp. 1163–1164; December, 1958.)

621.395.625:681.84.083.82 3550

Multitrack and Stereo Heads for Studio and Home Equipment—H. Haar. (*Radioschau*, vol. 9, pp. 224–225; June/July, 1959.) The design and construction of modern tape-recording heads are described.

ANTENNAS AND TRANSMISSION LINES

621.315.212:621.372.54 3551

A Broad-Band Microwave Coaxial Connector with Capacitive R.F. Coupling and Isolated D.C. Returns—C. M. Lin and R. W. Grow. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 454–455; October, 1958.) Description of the construction and characteristics of a modified Type-N connector which serves as a high-pass filter in the range 1.5 to 10 kmc.

621.315.212:621.372.62 3552

An Analysis of a Broad-Band Coaxial Hybrid Ring—V. J. Albanese and W. P. Peyser. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 369–373; Octo-

ber, 1958. Abstract, PROC. IRE, vol. 47, p. 112; January, 1959.)

621.372.8.002.2 3553
Manufacture of Waveguide Parts by Investment Casting from Frozen-Mercury Patterns—H. H. Scholefield, H. H. H. Green and R. E. Gossett. (*Proc. IEE* (*London*), Part B, vol. 106, pp. 431–434; July, 1959.) A discussion of the merits and limitations of the frozen-mercury process.

621.372.82 3554
The Cutoff Wavelength of Trough Waveguide—K. S. Packard. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 455–456; October, 1958.)

621.372.821 3555
A Method of Calculating the Characteristic Impedance of a Strip Transmission Line to a Given Degree of Accuracy—R. G. de Buda. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 440–446; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.372.821:621.372.832.43 3556
Coupled- Transmission-Line Directional Couplers—J. K. Shimizu and E. M. T. Jones. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 403–410; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.372.826 3557
The Estimation of the Reactance of a Loss-Free Surface Supporting Surface Waves—K. P. Sharma. (*Proc. IEE* (*London*), Part B, vol. 106, pp. 427–430; July, 1959.) A transmission-line analogue technique is applied in the calculation of the reactance of a loss-free flat surface, and the results are compared with experimental data.

621.372.826:537.226 3558
The Excitation of a Dielectric Rod by a Cylindrical Waveguide—C. M. Angulo and W. S. C. Chang. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 389–393; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.372.832 3559
The Multiple-Branch Waveguide Coupler—J. Reed. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 398–403; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.372.832.6 3560
Hybrid Junctions—R. Levy. (*Electronic Radio Eng.*, vol. 36, pp. 308–312; August, 1959.) 90° hybrids are not only compact and easy to construct but they retain their 90° phase-shift property over a wide band and are excellent when used as duplexers. The disadvantages of 180° hybrids, such as the hybrid-T, and of hybrid rings are pointed out.

621.372.852.1 3561
A Unified Discussion of High-Q Waveguide Filter Design Theory—H. J. Riblet. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 359–368; October, 1958. Abstract, PROC. IRE, vol. 47, p. 112; January, 1959.)

621.372.852.1 3562
High-Power Microwave Filters—J. H. Vogelman. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 429–439; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.372.852.323:621.318.134 3563
Development of a High-Power L-Band Resonance Isolator—E. O. Schulz-Dubois, G. J. Wheeler and M. H. Sirvetz. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 423–428; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.372.852.4:621.317.34 3564
Equipment for the Investigation of Polarization Properties of Transmission Elements in the 4-Gc/s Region—K. Baur. (*Arch. elekt. Übertragung*, vol. 12, pp. 371–379, 407–413 and 447–456; October, 1958.) The theory and design of *a*) a polarization converter for obtaining any desired elliptical polarization, and *b*) a polarization discriminator are described in detail. The application of these units to the measurement of the polarization characteristics of a waveguide element is detailed.

621.396.67:061.6.055 3565
U.R.S.I. Report on Antennas and Waveguides, and Annotated Bibliography—H. V. Cottony, R. S. Elliott, E. C. Jordan, V. H. Rumsey, K. M. Siegel, J. R. Wait, and O. C. Woodyard. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 87–98; January, 1959. Abstract, PROC. IRE, vol. 47, pp. 610–611; April, 1959.)

621.396.67.09 3566
The Radiansphere around a Small Antenna—H. A. Wheeler. (PROC. IRE, vol. 47, pp. 1325–1331; August, 1959.) Defines the radius (1 "radianlength" $=\lambda/2\pi$) at which the near and far fields of a small antenna are equal. The concept assists in visualizing the properties of small lossy antennas which are evaluated.

621.396.673.012.12 3567
On the Radiation Diagram of Linear Antennas—A. Bruaux. (*Rev. HF, Brussels*, vol. 4, no. 5 pp. 107–118; 1959.) Expressions are derived for calculating the radiation diagram of an asymmetrically energized cylindrical antenna. Results obtained at frequencies of 150 and 185 mc with an experimental antenna 1 m long and 81 mm in diameter, fed at a point several cm from one end are in good agreement with theoretical diagrams. See also 286 of 1951 (King).

621.396.676:621.318.57 3568
Optimizing Antenna Switches and Phasers—I. Dlugatch. (*Electronics*, vol. 32, pp. 55–57; August 14, 1959.) An automatic antenna switching circuit for aircraft is described, that can give a maximum increase of signal/noise ratio of 3 db and has a reduced tendency to lock on reflected or distorted signals.

621.396.677 3569
Travelling-Wave Cylindrical Antenna Design.—A Graphical Synthesis Method—P. Foldes. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 74–80; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.677 3570
The Theory of Helical Antennas—W. Peters. (*Nachrichtentech. Z.*, vol. 11, pp. 405–410; August, 1958.) The characteristics are calculated and methods of increasing the gain are discussed.

621.396.677:621.397.61 3571
Transmitting Antennas for Television Broadcasting in the United Kingdom—A. Brown. (*J. Brit. IRE*, vol. 19, pp. 389–399; July, 1959.) The permissible variation of reflection coefficient and of radiation pattern with frequency are considered and problems that arise in the design and testing of UHF antennas are discussed.

621.396.677.3 3572
The Superdirectivity of an Aerial for Tranverse Radiation—J. C. Simon, G. Broussaud and E. Spitz. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 2309–2311; April 20, 1959.) Superdirective antennas can only be obtained by grouping several independent sources in a volume which is small relative to the wavelength. Using an array of five slots concentrated in a length $3\lambda/4$ and fed from the same oscillator at 3 cm λ, a main-lobe width of 24° was obtained. The classical limit is 69°.

621.396.677.3:523.164.32 3573
16-Antenna Array operating at 9,300 Mc/s—Pick-Gutmann and Steinberg. (*See* 3659.)

621.396.677.3:621.376.5 3574
Improving Antenna Directivity for Pulsed Signals—V. G. Welsby. (*Electronic Radio Eng.*, vol. 36, pp. 313; August, 1959.) The usual antenna array designs are based on the amplitude and phase characteristics of the carrier wave. When pulse modulation is used, the pulse envelope delay between the outputs from two elements is disregarded. The utilization of this additional information requires further study.

621.396.677.31 3575
Suppressed Sidelobe Antenna of 32 Elements—G. Reber. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, p. 101; January, 1959.) Results are given for an array designed to operate at medium wavelengths with a 23 db sidelobe suppression.

621.396.677.43 3576
On the Design of some Rhombic Antenna Arrays—A. A. de C. Fernandes. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 39–46; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.677.45 3577
Radiation Field of an Elliptical Helical Antenna—J. Y. Wong and S. C. Loh. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 46–52; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959. See also 1776 of June.

621.396.677.47 3578
On the Optimum Radiation from a Sawtooth Antenna used at Microwave Frequencies—M. Anastassiades, C. Caroumbalos and C. Bouloheris. (*Ann. Télécommun.*, vol. 13, pp. 83–89; March/April, 1958.) A study of the antenna developed from V-antenna theory, shows that the optimum V-angle is 120°. The directivity is comparable with that of a parabolic mirror of equal surface area.

621.396.677.5 3579
The Rectangular Loop Antenna as a Dipole—R. King. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 53–61; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.677.71 3580
Conical Radiation from a Travelling-Wave Slot—J. Ernest. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 2463–2465; April 27, 1959.) A demonstration that the radiation field has the symmetry of a half cone is confirmed by experiments at 3.15 cm λ.

621.396.677.71.015.5 3581
Voltage Breakdown Characteristics of Microwave Antennas—J. B. Chown, W. E. Scharfman and T. Morita. (PROC. IRE, vol. 47, pp. 1331–1337; August, 1959.) Measurements made at X-band frequencies on a 20 db slot antenna are described. Voltage swr pulse shape, radiation pattern and radiated power all vary with pulse width and peak power.

621.396.677.73 3582
The Effect of Flanges on the Radiation Patterns of Waveguide and Sectoral Horns—P. C. Butson and G. T. Thompson. (*Proc. IEE (London)* Part B, vol. 106, pp. 422–426; July, 1959.) Radiation patterns are given for open-end rectangular waveguide (WG10) with conducting flanges attached to the long edges of the aperture. Some *E*-plane patterns of flanged *H*-plane sectoral horns are also given, and the results show differences between these patterns and those of similarly flanged waveguide.

621.396.677.85 3583
Spherically Symmetric Lenses—A. F. Kay (IRE TRANS ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 32–38; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.677.85:537.226 3584
Properties of Slotted Dielectric Interfaces—R. E. Collin. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp.62–73; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

AUTOMATIC COMPUTERS

681.142 3585
Testing High-Speed Digital Computer Circuits—R. G. Norquist. (*Electronics*, vol. 32, pp. 50–51; July 17, 1959.) A word generator providing 16-bit serial binary words at a rate of 10 mc is described. Any one of 2^{16} words can be selected manually. High-*gm* tetrodes are used to obtain high-speed operation.

681.142 3586
Automatic Input Equipment for Commercial Data Processing Systems—K. R. Eldredge, F. J. Kamphoefner and P. H. Wendt. (*Nachrichtentech. Z.*, vol. 11, pp. 393–397; August, 1958.) Magnetic equipment for "reading" documents with characters and symbols printed in magnetic ink is described. With a high-speed transporation arrangement, 5000 characters can be read and 50 documents handled per second.

681.142:621.318.042 3587
A Fast Method of Reading Magnetic-Core Memories—H. J. Heijn and N. C. de Troye. (*Philips Tech. Rev.*, vol. 20, pp. 193–207; February 10, 1959.) Description of a 1024-word, 44-bit storage system using a method of core-threading suggested by Renwick (2481 *f* of 1958). The system includes a circuit which prevents parasitic pulses from blocking the output amplifiers, reducing the cycling time to 3μs.

681.142:621.372.44 3588
The Parametron, a Digital Computing Element which Utilizes Parametric Oscillation.—E. Goto. (PROC. IRE, vol. 47, pp. 1304–1316; August, 1959.) Japanese research and applications of parametric oscillation are described. A parametron element is essentially a resonant circuit with a nonlinear reactive element oscillating at half the driving frequency. The oscillation is used to represent a binary digit by the choice between two stationary phases π radians apart.

681.142:621.372.45 3589
A Negative Resistance for D.C. Computers—Indiresan. (*See* 3605.)

681.142:621.373.029.6:621.372.44 3590
Microwave Parametric Subharmonic Oscillators for Digital Computing—F. Sterzer. (PROC. IRE, vol. 47, pp. 1317–1324; August, 1959.) The oscillation is used to represent a binary digit by the choice between the stationary phases π radians apart. A variable capacitance oscillator with output frequency 2 kmc is described, and its use for amplifying, scaling and performing logic functions is discussed. The advantages of carrier over baseband systems for high-speed computing are mentioned. (*See* 3588 above.)

681.142.001.4:621.373.44 3591
Dynamic Testing of Computer Building Blocks—R. W. Buchanan and B. Kautz. (*Electronics*, vol. 32, pp. 66–68; August 14, 1959.) A variable-frequencing pulse source with repetition frequency up to 18 mc is described.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.049:621.314.7 3592
Transistorizing Electronic Equipment—R. K. Jurgen. (*Electronics*, vol. 32, pp. 53–64; July 31, 1959.) A general discussion of semiconductor devices giving tabulated data on Ge and Si diodes and transistors, specifications of associated thermistors, capacitors and batteries, and a note on the construction of solid circuits.

621.314.2:621.372.51 3593
Some Broad-Band Transformers—C. L. Ruthroff. (PROC. IRE, vol. 47, pp. 1337–1342; August, 1959.) Describes the construction, theory and performance of transmission-line transformers, which take the form of twisted pairs having distributed interwinding capacitors. Bandwidth ratios as high as 20000:1 in the range 50 kc—1 kmc can be obtained, with transformation ratios of unity or 4:1.

621.314.2:621.372.51 3594
Some Notes on the Optimum Design of Stepped Transmission-Line Transformers—L. Solymar. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 374–378; October, 1958. Abstract, PROC. IRE, vol. 47, p. 112; January, 1959.)

621.314.2:621.372.512 3595
Double-Tuned Transformers — Steady-State and Transient Response—J. B. Rudd. (*AWA Tech. Rev.*, vol. 10, pp. 175–214; December, 1958.) A general analysis applicable to both wide- and barrow-band cases. All degrees of coupling are examined and expressions are derived for insertion loss, phase shift, envelope delay, rise time and overshot.

621.316.86 3596
Current Noise and Nonlinearity in Pyrolytic Carbon Films—T. R. Williams and J. B. Thomas. (*Rev. Sci. Instr.*, vol. 30, pp. 586–590; July, 1959.) A high correlation exists between noise and nonlinearity when the variations in film dimensions are taken into account. A balanced-bridge method for measuring nonlinearity is described.

621.318.57:621.314.63 3597
Microwave Semiconductor Switching Techniques—R. V. Garver, E. G. Spencer and M. A. Harper. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 378–383; October, 1958. Abstract, PROC. IRE, vol. 47, p. 112; January, 1959.)

621.318.57:621.314.7 3598
Switching Circuits for Missile Count-Downs—D. W. Boensel. (*Electronics*, vol. 32, pp. 76–78; July 31, 1959.) A transistor circuit is described which produces a switching pulse if its input differs by more than a predetermined amount from a given reference level. The use of nonlinear negative feedback ensures stable operation over a wide temperature range.

621.319.43.076.7 3599
Voltage-Variable Capacitor Selection Guide—T. W. Butler, Jr., and G. A. Roberts. (*Electronics*, vol. 32, pp. 52–53; July 24, 1959.) Tabulated information is presented to facilitate the choice of the best component for the circuit requirements.

621.372.01 3600
Elements of Electronic Circuits: Part 5—Amplitude Selection and Amplitude Comparison—J. M. Peters. (*Wireless World*, vol. 65, pp. 411–413; September, 1959.) Part 4: 3221 of October.

621.372.012 3601
Signal Flow Graphs—M. Boisvert. (*Ann. Télécommun.*, vol. 13, pp. 50–77; March/April, 1958.) An article in three parts covering basic theory, topological relations for network synthesis, and applications to feedback theory.

621.372.012 3602
Signal Flow Graphs—R. F. Hoskins. (*Electronic Radio Eng.*, vol. 36, pp. 298–304; August, 1959.) A discussion of the application of Mason's technique of circuit analysis (2985 of 1956 and 3531 of 1953.)

621.372.413/.414:621.372.54 3603
Dissipation Loss in Multiple-Coupled Resonator Filters—S. B. Cohn. (PROC. IRE, vol. 47, pp. 1342–1348; August, 1959.) A simple approximate formula enables center-frequency loss to be computed, and elsewhere loss may be computed from the prototype (low-pass) filter after suitable circuit modification. Unsymmetrical and symmetrical designs are considered.

621.372.414 3604
Miniature Resonators for U.H.F.—I. Dlugatch. (*Electronic Equipm. Engng.*, vol. 7, pp. 35–37; January, 1959.) An investigation of the extent of miniaturization possible in coaxial resonators.

621.372.45:681.142 3605
A Negative Resistance for D.C. Computers—P. V. Indiresan. (*J. Brit. IRE*, vol. 19, pp. 401–410; July, 1959.) A nomogram is presented for the design of a circuit using transistors and resistors to give any required value of negative resistance.

621.372.5 3606
Some Applications of Non-Euclidean Geometry in Quadripole Theory—E. F. Bolinder. (*Arch. elekt. Ubertragung*, vol. 12, pp. 357–361; August, 1958.) A survey of literature and an attempt to correlate the work of various authors. The treatment of impedance and noise transformations by means of the Poincaré and Cayley-Klein models of non-Euclidean hyperbolic space is discussed. 50 references.

621.372.54 3607
Novel Expression for the Relationship between the Real and Imaginary Parts of the Transfer Function of a Linear Filter—D. M. Lipkin. (PROC. IRE, vol. 47, p. 1383; August, 1959.)

621.372.543.2 3608
Theory and Design Data for the Synthesis of Tchebycheff Parameter Filters—W. Milort. (*Philips Telecommun. Rev.*, vol. 20, pp. 158–185; May, 1959.) 54 references.

621.373.029.6:621.372.44:681.142 3609
Microwave Parametric Subharmonic Oscillators for Digital Computing—Sterzer. (*See* 3590.)

621.373.029.65:621.314.63 3610
Experiment indicating Generation of Submillimetre Waves by an Avalanching Semiconductor—Schleimann-Jensen. (*See* 3875.)

621.373.4 3611
Ultraharmonic and Subharmonic Resonance in an Oscillator—B. R. Nag. (*J. Brit. IRE*, vol. 19, pp. 411–416; July, 1959.) Experimental results, using a differential analyser, are compared for an oscillator with cubic non-

linearity with theoretical curves obtained by Van der Pol's method.

621.373.431.1.076 3612
Frequency Control of Magnetic Multivibrators—W. A. Geyger. (*Electronics*, vol. 32, pp. 54–56; July 24, 1959.) A basic circuit is developed allowing output frequency to be controlled continuously or in steps over a wide frequency range. Variations of the circuit provide similar controls of output amplitude.

621.374:621.314.7 3613
Designing Transistor Circuits—Sequential Circuits: Parts 1 and 2—R. B. Hurley. (*Electronic Equipm. Engng.*, vol. 6, pp. 40–45; December, 1958. and vol. 7, pp. 54–58; February, 1959.) Bistable flip-flop, a stable and monostable multivibrator, blocking-oscillator, and negative-resistance circuits and transistor-reactor combinations are discussed.

621.374.44 3614
Stepping Up Frequency with Counter Circuits—W. O. Brooks. (*Electronics*, vol. 32, pp. 60–62; July 17, 1959.) Precise frequency multiplication is achieved with digital feedback, counter (divider) circuits, and a phase comparator. The circuit described multiplies frequencies between 900 and 1100 cps by a factor of 1000 with an error of 0.1 per cent.

621.375.2.078 3615
Reducing Errors caused by Power-Supply Variations—J. Holtzman. (*Electronics*. vol. 32, pp. 54–55; July 17, 1959.) Differential amplifiers in cascade cancel the errors.

621.375.227 3616
Concertina Phase - Splitter — (*Electronic Radio Engr.*, vol. 36, pp. 271–274 and 295–297; July and August, 1959.) The performance of the circuit is analysed with particular regard to the frequency range of operation.

621.375.3 3617
Graphical Determination of the Operating Characteristic of a Magnetic Amplifier—E. Pio. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 1960–1961; April 1, 1959.) A method of constructing a performance characteristic for a magnetic amplifier is described, based on the equivalent circuit derived earlier (3237 of October, Bernard and Pio) taking account of the nonlinearity of the associated rectifier and expressing output current as a function of current in the control circuit.

621.375.4 3618
Q-Multiplication with Transistors—A. E. Bachmann. (*Arch. elekt. Übertragung*, vol. 12, pp. 368–370; August, 1958.) Two transistor circuits are described with negative impedance stable to within 1 per cent over a temperature range −30° to +60°C. See also *Proc. NEC, Chicago*, vol. 12, pp. 469–480; 1956 (Karp).

621.375.432 3619
Feedback Design for Transistor Amplifier Stages—T. R. Hoffman. (*Electronics*, vol. 32, pp. 52–54; August 14, 1959.) Equations are given for realizing a specific input impedance, or maximum feedback for a given gain.

621.375.9:537.311.33 3620
Avalanche-Controlled Semiconductor Amplifier—L. J. Giacoletto. (*Proc.* IRE, vol. 47, pp. 1379–1381; August, 1959.) The theory of a particular avalanche-controlled semiconductor amplifier is given; its hf operation should be good.

621.375.9:538.569.4 3621
Three-Level Spin Refrigeration and Maser Action at 1500 Mc/s—Geusic, Shulz-Du Bois, De Grasse and Scovil. (*See* 3654.)

621.375.9:538.569.4 3622
Method for Calculating Simultaneous Resonance Conditions in a Three-Level Ruby Maser—M. A. Garstens. (*J. Appl. Phys.*, vol. 30, pp. 976–977; July, 1959.)

621.375.9:538.569.4.029.64 3623
Multilevel Pulsed-Field Maser for Generation of High Frequencies—S. Foner, L. R. Momo and A. Mayer. (*Phys. Rev. Lett.*, vol. 3, pp. 36–38; July 1, 1959.) The maser has been operated at 4.2°K as an oscillator at both 12.61 kmc and 1915 kmc with a pumping frequency of 12.61 kmc. Principles of operation and characteristics are discussed.

621.375.9:538.569.4.029.64 3624
Low-Field *X*-Band Ruby Maser—F. R. Arams. (Proc. IRE, vol. 47, pp. 1373–1374; August, 1959.) The signal frequency used was 9540 mc and the pump frequency 10850 mc. The low pump-frequency and low magnetic-field requirements are attractive although the achievable gain-bandwidth product is lower than with other masers.

621.375.9:621.3.011.23 3625
A Surface-Wave Parametric Amplifier—E. S. Cassedy, Jr. (Proc. IRE, vol. 47, pp. 1374–1375; August, 1959.) The proposed amplifier would take the form of a slab of ferroelectric material between two conducting planes. The slab would be pumped with high power. It is shown that useful gain would be achieved at X-band frequencies even with present ferroelectric materials. With new materials the amplifier could be used at mmλ.

621.375.9:621.3.011.23 3626
Relaxation Phenomena in Diode Parametric Amplifiers—H. Endler, A. D. Berk and W. L. Whirry. (Proc. IRE, vol. 47, pp. 1375–1376; August, 1959.) Oscillations have been observed in parametric amplifiers under certain conditions with CW pump sources. The effect varies with pump power, being a relaxation oscillation at low pump power, and a stable oscil ation when this is increased.

621.375.9:621.383:535.376 3627
Lumistors: Amplifiers of the Future—Spitzer. (*See* 3884.)

GENERAL PHYSICS

535.13 3628
Criterion of Uniqueness for the Solutions of Maxwell's Equations—P. Poincelot. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 2182–2184; April 13, 1959.) A linear medium characterized by the absence of dielectric or magnetic hysteresis is considered.

535.62 3629
Two-Coordinate Colour—(*Electronic Radio Engr.*, vol. 36, pp. 292–295; August, 1959.) A short discussion of the subjective and objective characteristics of a color and their relation to color vision. The two color experiments of Land (*Sci. Amer.*, vol. 200, pp. 84–94, 99; May, 1959.) are summarized and their bearing on Goethe's two color theory of 1808 and Granit's recent experiments.

537.291 3630
Grapho-analytical Plotting of Trajectories of Charged Particles in Variable Electric and Constant Magnetic Fields—N. I. Shtepa. (*Zh. Tekh. Fiz.*, vol. 28, pp. 178–187; January, 1958.) Two techniques are described based on a) addition of velocities, and b) radius of curvature. Examples of plotting using these two methods are shown. Errors and means of correcting them are indicated.

537.311.33:538.569.2 3631
The Phenomenon of Depolarization in Small Conducting Bodies in an Extensive Electromagnetic High-Frequency Field—H. Stols. (*Ann. Phys.* (*Lpz.*), vol. 1, pp. 334–343; June 2, 1958.) Continuation of earlier investigations (see 2117 of 1958). Current density and internal field are calculated as a function of the external field. The results are discussed with reference to measurements on Ge in the temperature range 0–200°C at 1.24 cmλ.

537.311.33:539.2 3632
Role of Negative Effective Mass in Negative Resistance—P. Kaus. (*Phys. Rev. Lett.*, vol. 3, pp. 20–23; July 1, 1959.) A theoretical investigation of the relations between negative effective mass, carrier distribution and negative resistance.

537.312.62 3633
Impurity Scattering in Superconductors—H. Suhl, and B. T. Matthias. (*Phys. Rev.*, vol. 114, pp. 977–988; May 15, 1959.) Perturbation theory is used to determine the reduction in superconducting transition temperature due to scattering by impurities dissolved in the superconductor.

537.533.7:538.561 3634
The Radiation from a Charged Particle Passing through a Plate—G. M. Garibyan and G. A. Chalikyan. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1282–1283; November, 1958.) Expressions are derived for the Fourier components of the radiation field in the space before and after a dielectric plate in vacuum.

537.533.7:538.561 3635
Motion of a Charged Particle in an Anisotropic Medium—G. A. Begiashvili and E. V. Gedalin. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1513–1517; December, 1958.) Expressions are derived for the em field components, and the total energy losses are determined for a charged particle moving in an anisotropic gyroelectric and gyromagnetic medium.

537.533.79:538.221 3636
Magnetic Perturbation of Cathode Rays—S. Yamaguchi. (*Nuovo Cim.*, vol. 10, pp. 714–717; November 16, 1958. In English.) The splitting of an electron beam when it penetrates a magnet was observed with electron-diffraction apparatus. An explanation is given in terms of polarization of free electrons.

537.534.9 3637
Ion-drag Pressure Generation—O. M. Stuetzer. (*J. Appl. Phys.*, vol. 30, pp. 984–994; July, 1959.) "A theory of pressure build-up under unipolar ion conduction is presented and verified experimentally. Constriction of the current flow leads to sizeable pressures in insulating liquids."

537.56:534.1–8 3638
On Acoustic-Electrical Phenomena in a Degenerate Electron-Ion Plasma—P. S. Zyryanov and G. G. Taluts. (*Zh. Eksp. Teor. Fiz.*, vol. 36, pp. 145–148; January, 1959.) A calculation of the absorption coefficient for ultrasonic waves travelling in a plasma.

537.56:538.56 3639
Low-Frequency Oscillations of Plasma in a Magnetic Field—K. N. Stepanov. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1155–1160; November, 1958.) Mathematical analysis of small oscillations of a plasma consisting of electrons and singly charged ions. Some limiting cases are discussed for which a solution of the dispersion equation can be found.

537.56:538.56 3640
On the Behaviour of a Conducting Gaseous Sphere in a Quasistationary Electromagnetic Field—V. V. Yankov. (*Zh. Eksp. Teor. Fiz.*, vol. 36, pp. 560–564; February, 1959.) Investigation by the perturbation method of the sta-

bility of a homogeneous plasma sphere with an external field.

537.56:538.566 3641
Statistical Derivation of the Dispersion Formula of a Lorentz Plasma of Finite Temperature—K. Rawer and K. Suchy. (*Ann. Phys.* (*Lpz.*), vol. 2, pp. 313–325; November 11, 1958.)

537.56:538.63 3642
An Investigation on Plasmas in External Magnetic Fields: Part 1—Steady State, Part 2—Varying Fields—G. Schmidt. (*Nuovo Cim.*, vol. 10, pp. 55–67 and 659–674; October 1, and November 16, 1958. In English.)

537.562:538.63 3643
Dependence of Electron Mobility on Magnetic Field in a Fully Ionized Gas—M. S. Sodha and Y. P. Varshni. (*Phys. Rev.*, vol. 114, pp. 946–947; May 15, 1959.) Analysis, with tabulations and illustrative graphs, of the variation of drift and Hall mobilities with magnetic field.

538.1 3644
A System of Magnetic Moments in a Weak Variable Magnetic Field—G. V. Skrotskiĭ and A. A. Kokin. (*Zh. Eksp. Teor. Fiz.*, vol. 36, pp. 169–175; January, 1959.) A mathematical analysis of a system of magnetic moments which possesses electric exchange and weak magnetic dipole-dipole interactions and which is located in an external magnetic field. The equation of matron of the magnetization vector is derived and the limits of its applicability are discussed.

538.221 3645
On Magnetic Permeability for the Case of Magnetization under the Action of a Circular Alternating Field in the Presence of a D.C. Longitudinal Field—V. Tutovan. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 940–943; February 16, 1959.) A method is described for measuring the permeability of a torsion-free iron wire. Results are given for various values of the circular alternating field, the longitudinal field and the wire tension.

538.221:538.569.4 3646
Ferromagnetic Resonance in a Circularly Polarized Electromagnetic Field of Arbitrary Amplitude—G. V. Skrotskiĭ and Yu. I. Alimov. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1481–1484; December, 1958.) The exact solution of the magnetization equations of motion is examined. The dependence of the magnetization components on the amplitudes of the magnetizing field and RF field is determined.

538.561:537.122 3647
Cherenkov Radiation from Dipoles—V. L. Ginzburg and V. Ya. Eĭdman. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1508-1512; December, 1958.) Mathematical analysis of the Cherenkov radiation from electric and magnetic dipoles moving in a continuous medium in a channel or a slit.

538.561:537.122 3648
On the Cherenkov Radiation of an Electron Moving in a Medium with Spatial Dispersion—V. N. Agranovich, V. E. Pafomov, and A. A. Rukhadze. (*Zh. Eksp. Teor. Fiz.*, vol. 36, pp. 238–243; January, 1959.) An examination of the Cherenkov radiation in an isotropic medium including a consideration of spatial dispersion. The angular distribution of the radiation intensity and the escape of the radiation through the surface of the medium are discussed.

538.561:539.17 3649
Radio Emission from an Atomic Explosion—A. S. Kompaneets. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1538–1544; December, 1958.) In an atomic explosion which is accompanied by asymmetric emission of γ quanta, radio waves are emitted due to the presence of a current in the ionized air. The duration of the oscillation in each half-wave is of the order of 10 μs. For a given asymmetry in emission of the γ rays, the amplitude of the oscillations depends weakly on the total number of quanta.

538.561:662.2 3650
Emission of Radio Waves from Detonations—B. Koch. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 2173–2175; April 13, 1959.) Transient em waves giving a field strength of about 600μv/m close to an explosion of 750g of high explosive were recorded using a receiver tuned to 24.1 mc. They are attribtued to ionic rather than thermal effects. See 1741 of 1954 (Kolsky).

538.566.2:539.32 3651
Discussion of the Influence of Frequency in the Problem of the Investigation of the Optimum Absorption Thickness for a Metallic Thin Film—M. Gourceaux. (*Compt. Rend. Acad. Sci., Paris*, vol. 248, pp. 2461–2462; April 27, 1959.) The absorption of em waves by films so thick as to be equivalent to the solid material and by very thin films is considered.

538.569.4:538.222 3652
Spectral Diffusion, Phonons, and Paramagnetic Spin-Lattice Relaxation—P. W. Anderson. (*Phys. Rev.*, vol. 114, pp. 1002–1005; May 15, 1959.) Discussion of paramagnetic relaxation phenomena at low temperatures, by analogy with Holstein's theory of trapping of resonance radiation in gases.

538.569.4:[538.222+537.311.33 3653
On the Overhauser Stationary Effect in Paramagnetic Salts and Semiconductors—G. R. Khutsishvili. (*Nuovo Cim.*, vol. 11, pp. 186–197; January 16, 1959. In English.) Discussion of the problem of obtaining stationary nuclear polarization in nonmetals by means of a complete or partial saturation of one or more components of the para-magnetic-resonance hyperfine structure.

538.569.4:621.375.9 3654
Three-Level Spin Refrigeration and Maser Action at 1500 Mc/s—J. E. Geusic, E. O. Shulz-Du Bois, R. W. De Grasse and H. E. D. Scovil. (*J. Appl. Phys.*, vol. 30, pp. 1113–1114; July, 1959.) It is shown that positive and negative signal spin temperatures, both small compared to the ambient temperature, can be realized through three-level excitation.

538.569.4:621.375.9:535.61-1/2 3655
Optical Maser Design—J. H. Sanders. (*Phys. Rev. Lett.*, vol. 3, pp. 86–87; July 15, 1959.) Excitation by electron impact is suggested for a maser working in the visible region. See 1857 of June (Schawlow and Townes).

538.569.4:621.375.9:537.52 3656
Possibility of Production of Negative Temperature in Gas Discharges—A. Javan. (*Phys. Rev. Lett.*, vol. 3, pp. 87–89; July 15, 1959.) The production of negative temperature by the excitation of atomic levels is suggested and the difficulties of obtaining sufficient excited atoms for maser action are considered.

537/538 3657
Handbuch der Physik (Encyclopedia of Physics). Vol. 16: Electric Fields and Waves. [Book Review]—S. Flügge (Ed.). Publishers: Springer-Verlag, Berlin-Göttingen-Heidelberg, 753 pp., DM 158, 1958. (*Naturwiss.*, vol. 45, no. 17, p. 427; Spetember, 1958.) The volume comprises the following five parts:

a) **Static Fields and Stationary Currents**—G. Wendt (In German).

b) **Quasi-Stationary and Nonstationary Currents in Electric Circuits**—R. King (In English).

c) **Electromagnetic Waveguides and Resonators**—F. E. Borgnis and C. H. Papas (In English).

d) **Propagation of Electromagnetic Waves**—H. Bremmer (In English).

e) **The Dispersion and Absorption of Electromagnetic Waves**—L. Hartshorn and J. A. Saxton (In English).

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.164.3 3658
Angular Diameter Measurements of the Radio Sources Cygnus (19N4A) and Cassiopeia (23N5A) on a Wavelength of 10.7 cm—B. Rowson. (*Monthly Notices Roy. Astron. Soc.*, vol. 119, no. 1, pp. 26–33; 1959.) Results, given in each case for two directions at right angles, show that Cassiopeia is circularly symmetrical and approximately the same size at 10.7 cm as it is at metre wavelengths, while Cygnus is markedly asymmetrical, with a major axis which may be slightly larger at the shorter wavelength. The position angle of this major axis is 109°±2°. Measurement equipment is described.

523.164.32:621.396.677.3 3659
16-Aerial Array operating at 9,300 Mc/s—M. Pick-Gutmann and J. L. Steinberg. (*Compt. Rend. Acad., Sci., Paris*, vol. 248, pp. 2452–2464; April 27, 1959.) An array of mirrors 1.10 m in diameter mounted at equal intervals on a beam 23 m long has been erected at Nancay for the study of RF solar radiation by interferometry. Centers of RF emission are found closely associated with optical centers.

523.164.4 3660
The Radio Emission from the Direction of the "Supergalaxy"—J. R. Shakeshaft and J. E. Baldwin. (*Monthly Notices Roy. Astron Soc.*, vol. 119, No. 1, pp. 46–53; 1959.) An analysis of observations made at 1.9 mλ suggests that the band of radio emission running perpendicular to the galactic plane, at about 12^h R. A. is not associated with the "local supergalaxy."

523.165 3661
Theory of the Cosmic-Ray Equator—R. Ingraham. (*Nuovo Cim.*, vol. 12, pp. 356–368; May 16, 1959. In English.) The 45° westward shift of the cosmic ray equator from the geomagnetic equator is explained by assuming that there exist ionized atmospheric layers which rotate more slowly than the earth. The resultant magnetic field beyond the layers is then a dipole field whose magnetic north pole is west of the geomagnetic north pole.

523.165:550.38 3662
Effect of Magnetic Anomaly on Particle Radiation Trapped in Geomagnetic Field—A. J. Dessler. (*J. Geophys. Res.*, vol. 64, pp. 713–715; July, 1959.)

523.165:550.389.2:629.19 3663
Investigation of Variations in Cosmic Radiation—S. N. Vernov, Yu. I. Logachev, A. E. Chudakov and Yu. G. Shafer. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 149–162; September, 1957.) The phenomena which can be investigated and the measuring instruments which can be installed in an artificial earth satellite are described.

523.72 3664
Investigation of Ultraviolet Solar Radiation—S. L. Mandel'shtam and A. I. Efremov. (*Uspekhi Fiz. Nauk*, vol. 63, pp. 163–180; Sept., 1957.)

523.746 3665
On the Structure and Mechanism of Sunspots—A. Dauvillier. (*Compt. Rend. Acad.*

Sci., Paris, vol. 248, pp. 1084–1086; February 23, 1959.)

523.75 3666

On a Possible Mechanism of Solar Non-Stable Processes leading to Neutron Eruptions—V. A. Petukhov. (*Ann. Géophys.*, vol. 14, pp. 425–432; October/December, 1958. In English.) The hypothesis is proposed that the formation within the sun of a nucleus with increased lithium concentration may be the initial cause of nonstable processes of all kinds and, in particular, the formation of sunspots.

550.38:551.510.535:621.396.11 3667

The Geometry of the Earth's Magnetic Field at Ionospheric Heights—Millman. (*See* 3849.)

550.385 3668

Induced Electromagnetic Fields in the Earth—J. Carstoiu (*Proc. Nat. Acad. Science, Wash.*, vol. 45, pp. 204–208; February, 1959.) A general theoretical study of the effect of geomagnetic variations in the earth.

550.385:539.16 3669

Geomagnetic Effects of Nuclear Explosions—(*Tech. Bull. Nat. Bur. Stand.*, vol. 43, pp. 121–122; July, 1959.) Report of an analysis of changes in the earth's magnetic field which occurred when two bombs were exploded at night at a high altitude on Johnston Island, August 1 and 12, 1958. Results indicate that the upper atmosphere at a distance of 2000 km was ionized to near daytime intensity. Field changes were detected up to 3400 km away. For a shorter account see *Electronics*, vol. 32, p. 72; August 14, 1959.

550.385:539.16 3670

Geomagnetic Disturbances due to Nuclear Explosion—H. Maeda. (*J. Geophys. Res.*, vol. 64, pp. 863–864; July, 1959.) Possible reasons for the observed effects at Honolulu on August 1 and 12, 1958, are discussed.

550.385:539.16 3671

Magnetic Effects resulting from Two High-Altitude Nuclear Explosions—J. A. Lawrie, V. B. Gerard and P. J. Gill. (*Nature*, vol. 184, pp. B.A. 34, B.A. 52; September 5, 1959.) An examination of vector diagrams of geomagnetic variations in a horizontal plane due to explosions on August 1 and 12, 1958, indicates that the effects may be classified into four phases; initial, second, main and final.

550.385:539.16 3672

Some Geomagnetic Phenomena associated with Nuclear Explosions—R. G. Mason and M. J. Vitousek. (*Nature*, vol. 184, pp. B.A. 52–B.A. 54; September 5, 1959.) Magnetograms recorded at three stations in the immediate area of the explosion on April 28, 1958, show no disturbance of the H component of the earth's field at the time of major disturbances in Z and D components. Vector diagrams of the disturbance in the vertical plane at the three stations are compared with those for the explosion on August 1, 1958, and are found to be markedly similar despite the different geographical positions and altitudes of the two events; in the latter event changes in the H component were comparable with those in Z and D.

550.385.37:551.510.536 3673

Geomagnetic Pulsations and the Earth's Outer Atmosphere—T. Obayashi. (*Ann. Géophys.*, vol. 14, pp. 464–474; October/December, 1958. In English.) Hydromagnetic oscillations of the ionized outer atmosphere are considered as a possible cause of geomagnetic pulsations. Observational results are applied to this model and the distribution of ionic density is determined.

550.389.2:061.3 3674

Important Contribution to International Scientific Collaboration—V. V. Belousov and B. I. Silkin. (*Priroda*, pp. 65–73; February, 1959.) A brief report on the Fifth Assembly of the Special I.G.Y. Committee which took place in Moscow, August 1958. 400 delegates from 35 countries were present and some preliminary results were discussed.

550.389.2:629.19 3675

Some Dynamic Problems of Flight to the Moon—V. A. Egorov. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 73–117; September, 1957.) Trajectories for reaching the moon or for flying round the moon and returning to the earth are considered. The initial rocket velocities and the distances from the earth and moon of four different orbits are tabulated. A periodic orbit passing near the moon and earth seems to be unpractical because an error in the initial velocity of 1 mm/sec would be enough to allow the rocket to escape into space after only four revolutions. For a shorter account see *Priroda*, pp. 3–9; February, 1958.

550.389.2:629.19 3676

The Launching of a Cosmic Rocket towards the Moon—(*Priroda*, pp. 1–4; January, 1959.) A short account of the day-to-day progress of the cosmic rocket from January 2–5, 1959. In the first 62 hours it travelled to a distance of 597,000 km passing the moon and entering an orbit around the sun between those of the earth and Mars.

550.389.2:629.19 3677

The Launching of Cosmic Rockets and Astronomical Problems—B. V. Kukarkin. (*Priroda*, pp. 7–8; March, 1959.)

550.389.2:629.19 3678

Soviet Cosmic Rocket—(*Priroda*, pp. 17–30; February, 1959.) A description of the 1472-kg rocket which was fired on January 2, 1959, and which passed within a distance of 5000–6000 km of the moon. The orbit round the sun lies between the earth and Mars and has a period of 15 months. The minimum and max mum distances from the sun will be 146 and 197×10^6 km. Signals were emitted from the rocket on 19.997, 19.995 and 19.993 mc. The eccentricity of the orbit is 0.148 as compared with 0.017 for the earth. A photograph of the sodium cloud released at a distance from the earth of 113,000 km is shown.

550.389.2:629.19 3679

Satellites and Space Probes Launched in U.S. and U.S.S.R.—(*Electronics*, vol. 32, pp. 46–47; July 24, 1959.) A tabulated summary of launching dates, instrumentation and results.

550.389.2:629.19 3680

Some Variational Problems connected with the Launching of an Artificial Earth Satellite—D. E. Okhotsimskiĭ and T. M. Eneev. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 5–32; September, 1957.) A mathematical analysis of the best angle of elevation for a rocket which is required to put a satellite into an orbit with minimum fuel consumption and allowing for a variable gravitational field and the rotation of the earth.

550.389.2:629.19 3681

Determination of the Lifetime of an Artificial Earth Satellite and Study of the Secular Perturbations of Its Orbit—D. E. Okhotsimskiĭ., T. M. Eneev and G. P. Taratynova. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 33–50; September, 1957.) A general mathematical method is described which is valid for any satellite and which takes account of the distribution of atmospheric density with altitude. This method is based on single-parameter series of integral curves of a first-order equation. From graphs and tables the satellite's lifetime and the variation of the orbital parameters with time are rapidly calculated. The effect of atmospheric rotation on the secular variations of the satellite's orbit are found to be small.

550.389.2:629.19 3682

The Motion of an Artificial Satellite in the Noncentral Field of Terrestrial Gravitation in the Presence of Atmospheric Resistance—G. P. Taratynova. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 51–58; September, 1957.) The orbit of a fictitious satellite of weight 10 kg and diameter 0.5 m has been calculated in four hours using an electronic computer. The period of rotation of the perigee is 11 times in 700 days. The ascending node regresses in the direction opposite to the earth's rotation at a rate of about 5° per day.

550.389.2:629.19 3683

Effect of Geophysical Factors on the Motion of a Satellite—I. M. Yatsunksiĭ. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 59–71; September, 1957.) The orbital calculations based on the use of differential equations in terms of elliptical osculating elements depend on the accurate estimation of geophysical factors such as air resistance and gravitational anomalies. The determination of these factors from satellite is considered.

550.389.2:629.19 3684

Use of Artificial Earth Satellites for the Verification of the General Theory of Relativity—V. L. Ginzburg. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 119–122; September, 1957.) Three main points could be examined: a) the rotation of the perigee of Mercury which, according to the theory, should revolve 43.03 inches in a century, b) the deflection by 1.75 inch of light rays in passing near the sun, c) the gravitational shift of spectral lines.

550.389.2:629.19 3685

The Orbit of Satellite 1958δ 2—G. Hergenhahn. (*Naturwiss.*, vol. 45, pp. 434–435; September, 1958.) Orbital period as a function of the number of revolutions completed is plotted for the period May 15 to July 2, 1958. Orbital data are calculated and certain discrepancies with observations are discussed.

550.389.2:629.19 3686

An Experimental and Indirect Method for Determining the High Atmosphere's Density—C. Casci and V. Giavotto. (*Nuovo Cim.*, vol. 11, pp. 291–297; January 16, 1959. In English.) An approximate method is described for calculating the density of the atmosphere above 130 km, using, as data, observed lifetimes of artificial satellites no longer in orbit. Calculated densities are compared with those measured by means of rocket probes.

550.389.2:629.19 3687

New Approach in the Theory of Satellite Orbits—J. P. Vinti. (*Phys. Rev. Lett.*, vol. 3, p. 8; July 1, 1959.) A proposed co-ordinate system is useful for investigating the motion of an earth satellite.

550.389.2:629.19 3688

Short-Time Measurement of Time Dilation in an Earth Satellite—R. S. Badessa, R. L. Kent and J. C. Nowell. (*Phys. Rev. Lett.*, vol. 3, pp. 79–80; July 15, 1959.) A method for measuring the gravitational red shift based on the variation of the frequency difference between two oscillators as a function of altitude.

550.389.2:629.19 3689

Air Density in the Upper Atmosphere from Satellite Orbit Observations—G. V. Groves. (*Nature*, vol. 184, Suppl. No. 4, pp. 178–179; July 18, 1959.) The results given agree with those of King-Hele (2955 of September).

550.389.2:629.19:523.165 3690
Investigation of Cosmic Rays by Means of Artificial Earth Satellites—N. A. Dorbrotin. (*Priroda*, pp. 57–64; January, 1959.) These investigations led to the discovery of a belt of charged particles round the earth which, at a height of 1600 km, passed at the rate of 10^8–10^9 particles per second through an area $1cm^2$. This radiation would be very dangerous to unprotected living beings.

550.389.2:629.19:523.165 3691
Ionizing Radiation at Altitudes of 3500 to 36000 Kilometres: Pioneer I—A. Rosen, C. P. Sonett, P. J. Coleman, Jr., and C. E. McIlwain. (*J. Geophys. Res.*, vol. 64, pp. 709–712; July, 1959.) "The total ionizing component of cosmic radiation was measured on October 11, 1958, by means of an ionization chamber mounted on the Pioneer I lunar probe vehicle. Data were taken over an altitude range of 3500 to 36000 km and a latitude range of 35°N to 5°N. The calibration procedure and the analysis of the telemetered data are described."

550.389.2:629.19:523.165 3692
Satellite Observations of Solar Cosmic Rays—P. Rothwell and C. McIlwain. (*Nature*, vol. 184, pp. 138–140; July 18, 1959.) On three occasions during August, 1958, large increases in the intensity of charged particles outside the Van Allen radiation zones were detected by 1958 E at high magnetic latitudes and low satellite altitudes. It is suggested that these increases are due to solar protons associated with large solar flares.

550.389.2:629.19:550.38 3693
Investigation of the Earth's Magnetic Field using an Artificial Earth Satellite—N. V. Pushkov and S. Sh. Dolginov. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 645–656; December, 1957.) An investigation by means of magnetometers, located on the satellite, of the space distribution of the earth's magnetic field at great heights and of inhomogeneities in the ionosphere. The effect of the magnetic field on the polarization of radio waves reflected from the ionosphere, the latitude effect of cosmic rays, and auroral phenomena are considered.

550.389.2:629.19:551.510.53 3694
Problems of Measurement of the Pressure and Density of the High Layers of the Atmosphere by means of Artificial Earth Satellites—B. S. Danilin, V. V. Mikhnevich, A. I. Repnev and E. G. Shvidkovskiĭ. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 205–226; September, 1957.) Temperature pressure, density and composition between 100 and 300 km are tabulated. The concentrations of oxygen and nitrogen between 160 and 500 km are also shown.

550.389.2:629.19:551.510.53 3695
The Density of the Earth's Outer Atmosphere according to Satellite Observations—H. K. Paetzold and H. Zschörner. (*Naturwiss.*, vol. 45, pp. 485–486; October, 1958.) Orbital data of satellites 1958α and 1958β 2 are used to determine atmospheric density above 200 km. Results agree closely with those obtained from observations of satellites 1957α 2 and 1958δ 2. Retardation effects are also discussed.

550.389.2:629.19:551.510.535 3696
Measurement of the Concentration of Positive Ions along the Orbit of an Artificial Earth Satellite—K. I. Gringauz and M. Kh. Zelikman. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 239–252; September, 1957.) The surface potential of a satellite and the distribution of charged particles around it are discussed. Instruments for measuring the ion concentration and the transmission of results to earth by radio-telemetry are described. Graphs of the air temperature at different heights are also shown. 23 references.

550.389.2:629.19:621.396.11 3697
Preliminary Results of Measurements on Doppler Shift of Satellite Emissions—P. R. Arendt. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 99–101; January, 1959.) Measurements of transmissions from 1957 α and β on 20 and 40 mc have been analyzed to investigate the influence of the propagation path on observed data. Results indicate that the 40-mc wave travels about 2 per cent slower than the 20-mc wave.

550.389.2:629.19:621.396.11 3698
Refraction of Very-High-Frequency Radio Signals at Ionospheric Heights—S. Weisbrod and L. Colin. (*Nature*, vol. 184, p. 119; July 11, 1959.) Calculations relevant to the radio tracking of space vehicles show that refractive errors due to the troposphere rapidly decrease with increasing elevation angle, while those due to the ionosphere initially increase with elevation angle and then decrease gradually. The elevation angle error is plotted for realistic models of the ionosphere and troposphere.

550.389.2(54) 3699
Work Carried Out under the Auspices of the Indian National Committee for the I.G.Y. 1957–1958—(*J. Sci. Indus. Res.* vol. 17A, Suppl., pp. 1–110; December, 1958.) The following papers and data are included:

a) **A Preliminary Report "On the Nature and Origin of Atmospherics"**—M. W. Chiplonkar, R. N. Karekar, T. A. Raju and M. S. Hattiangadi (pp. 3–23).

b) **Atmospheric Electricity Observations in India during the I.G.Y.—Radiosonde Techniques for Measuring Potential Gradient and Conductivity**—S. P. Venkeitshwaran (pp. 24–32).

c) **Geomagnetic Work at Albiag, Annamalainagar and Trivandrum during the I.G.Y.**—S. L. Malurkar (pp. 33–35).

d) **Atomic Nitrogen in the Thermosphere**—M. Nicolet (p. 36).

e) **Ionospheric Disturbances at Low Latitudes**—A. P. Mitra (pp. 37–40).

f) **Studies of Cosmic Radio Noise on 25 Mc/s at Ahmedabad**—R. V. Bhonsle and K. R. Ramanathan (pp. 40–45).

g) **Meteors and E_s Ionization**—K. M. Kotadia (pp. 46–49).

h) **Rates of Fading of Reflected Pulses of Vertically Incident Electromagnetic Waves at Ahmedabad on 2.6 and 4.0 Mc/s**—R. Sethuraman (pp. 50–53).

i) **Observations on Galactic Radiation at 30 Mc/s**—Y. V. Somayajulu and N. N. Rao. (pp. 54–56).

j) **Diurnal Variation of Ionospheric Absorption on 5.65 Mc/s at Waltair during the I.G.Y.**—B. R. Rao and K. V. V. Ramana (pp. 56–58).

k) **Effect of Enhanced Solar Activity on the F_2 Region Drifts at Waltair**—B. R. Rao and E. B. Rao (pp. 59–62).

l) **A New Continuous-Wave Radio Method for the Study of Ionospheric Drifts**—B. R. Rao and D. S. Murty (pp. 63–67).

m) **Program of I.G.Y. Solar Observations in India** (pp. 68–69).

n) **Solar Control of some Unusually Remarkable Geophysical Events**—S. L. Malurkar (pp. 69–71).

o) **Radio Emission from the Sun at 30 Mc/s**—M. Krishnamurthi, G. S. Sastry and T. S. Rao (pp. 71–73).

p) **Radio Patrol of Solar Flares**—A. P. Mitra, K. A. Sarada, N. V. G. Sarma and M. N. Joshi (pp. 74–80).

q) **Optical Tracking of Artificial Satellites**—M. K. Vainu Bappu (pp. 95–98).

Appendix 3:

r) **Table 1—Solar Flares during July 1957 to September 1958** (pp. 106–108).

s) **Table 2—Sudden Enhancement of Atmospherics (SEA) during July 1957 to August 1958** (p. 109).

t) **Table 3—Sudden Cosmic Absorption (SCA) during July 1957 to July 1958** (p. 109).

u) **Table 4—Solar Flare Effects recorded during July 1957 to June 1958** (p. 110).

551.510.53 3700
Investigation by Rockets of the Composition of the Atmosphere at Great Heights—B. A. Mirtov. (*Uspekhi. Fiz. Nauk.* vol. 63, pp. 181–196; September, 1957.) A description of containers designed to collect samples of the atmosphere is given and results obtained between 65 and 95 km are tabulated.

551.510.53 3701
Measurements of the Pressure in the Upper Atmosphere—V. V. Mikhnevich. (*Uspekhi. Fiz. Nauk* vol. 63 pp. 197–204; September, 1957.) A description is given of a container with recording instruments which, after being released from a rocket, record the pressure of the upper atmosphere. A comparison is made between pressure measurements obtained in U.S.A. and U.S.S.R. at 50–100 km. Pressure and temperature variations at different heights are shown graphically.

551.510.535 3702
Investigation of the Ionic Composition of the Ionized Layers of the Atmosphere—B. A. Mirtov and V. G. Istomin. (*Uspekhi. Fiz. Nauk.* vol. 63, pp. 227–238; September, 1957). Rockets and artificial satellites equipped with mass spectrometers of the type described by Bennett (*J. Appl. Phys.*, vol. 21, pp. 143–149; February, 1950) automatically sending results to the earth are considered. The ionization of the atmosphere by a fast-moving satellite vehicle and the effect of the vacuum created behind it are also examined.

551.510.535 3703
Results obtained with Rocket-Borne Ion Spectrometers—C. Y. Johnson, J. P. Heppner, J. C. Holmes and E. B. Meadows. (*Ann. Géophys.*, vol. 14, pp. 475–482; October/December, 1958. In English.) A description of the instrumentation used and an analysis of the results obtained from three flights in which both positive and negative ion spectrometers were flown.

551.510.535 3704
Some Studies of the Upper Atmosphere in the Auroral Zone—S. Matsushita. (*Ann. Géophys.*, vol. 14, pp. 483–491; October/December, 1958. In English.) Observations show close correlation between blackouts, complete blanketing of F_2 by E_s, slant E_s and geomagnetic bay disturbances. The height of the absorbing region responsible for the daytime polar blackout appeared to be lower than when the event occurred at night. To explain these results, the effect on the ionosphere of X-rays generated by solar particles is discussed.

551.510.535 3705
Model of the Ionosphere—O. Burkard. (*Naturwiss.*, vol. 45, pp. 507; November, 1958.) Electron-density data obtained by a Russian rocket can be correctly interpreted by the F_2-layer model proposed in *Geofis. pura appl.*, vol. 37, pp. 145–164; 1957.

551.510.535 3706
The Worldwide Distribution of the F_2-Layer Electron Density: Seasonal and Nonseasonal Variations and Correlations with Solar Activity—F. Mariani. (*Nuovo Cim.*, vol. 12, pp. 218–240; May 1, 1959. In English.) Seasonal and nonseasonal variations of the maximum electron density in the F_2 layer at noon are largely asymmetrical in the two hemispheres; at midnight they are symmetrical. A general circulation of the upper atmos-

phere is suggested as an explanation for these and other anomalies discussed. See 2444 of 1957.

551.510.535 3707

The Diurnal Development of the Anomalous Equatorial Belt in the F_2 Region of the Ionosphere—R. G. Rastogi. (*J. Geophys. Res.*, vol. 64, pp. 727–732; July, 1959.) A study is made of the latitudinal distribution of f_0F_2, for each hour of the day, for the equinoctial months at sunspot minimum and also of the diurnal variation of f_0F_2 at a number of low-latitude stations. The observed behaviour of f_0F_2 in both cases is suggested to be due not only to vertical drift of ionization but also to horizontal movement between the poles and the equator during the day.

551.510.535 3708

Time and Height Variations in the Daytime Processes in the Ionosphere: Part 1—A. P. Mitra, (*J. Geophys. Res.*, vol. 64, pp. 733–743; July, 1959.) An extension of earlier work (114 of 1955, Mitra and Jones). Variations of the decay of electron density with height are discussed for the height range 50–600 km. An expression is developed for the loss coefficients over this range for northern middle latitudes at noon.

551.510.535+550.385]:539.16 3709

Geomagnetic and Ionospheric Pheonomena associated with Nuclear Explosions—S. Matsushita. (*Nature*, vol. 184, pp. B.A.33–B.A.34; September 5, 1959.) Magnetograms and ionograms recorded at stations in the Central Pacific Ocean have been analyzed for the periods covering the explosions on August 1 and 12, 1958. Some geomagnetic variation could be explained by a dynamo effect associated with wind velocities of 100 miles per second and a ten-fold increase in electrical conductivity.

551.510.535:539.16 3710

Some Effects of Nuclear Explosions on Ionospheric Vertical-Incidence Soundings—D. Lepechinsky and C. Davoust. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 1203–1206; February 23, 1959.) An analysis of observations made at Tahiti (17°20′S, 149°20′W), Maui (20°N, 150°W) and Rarotonga (21°12′S, 159°46′W). At the time of an explosion on August 1, 1958. abnormal absorption, which lasted three hours, was recorded at Maui and Tahiti (for auroral effect see 1569 of May, Cullington). On August 12, 1959, the date of another explosion, the onset of abnormal absorption at Maui and Rarotonga appeared to be delayed by five hours.

551.510.535:539.16 3711

Sudden Ionospheric Disturbances caused by an Atomic Explosion—A. Kimpara. (*Compt. rend. Acad. Sci. Paris*, vol. 248, pp. 2117–2119; April 6, 1959.) A note on recordings of atmospherics and solar RF bursts made at Toyokawa, Japan, August 12, 1958.

551.510.535:539.16 3712

Disturbance in the Ionospheric F Region following the Johnston Island Nuclear Explosion—C. H. Cummack and G. A. M. King. (*Nature*, vol. 184, pp. B.A.32–B.A.33; September 5, 1959.) From a study of time delay at various observatories in the vicinity, it is assumed that the ionospheric disturbance due to the explosion on August 1, 1958, is a by-product of a gaseous shock wave propagated at a velocity considerably greater than that of sound. Anomalies in this assumption are discussed.

551.510.535:550.371 3713

Measurement of Electrostatic Fields in the Upper Layers of the Earth's Atmosphere—I. M. Imyanitov. (*Uspekhi. Fiz. Nauk*, vol. 63, pp. 267–282; September, 1957.) The charge acquired by a body located in a plasma is examined. An instrument measuring the field potential in the ionosphere is described. Electrostatic field variations due to moving rockets or satellites are considered.

551.510.535:621.396.11 3714

Ionosphere Electron Densities and Differential Absorption—J. C. Seddon and J. E. Jackson. (*Ann. Géophys.*, vol. 14, pp. 456–463; October/December, 1958.) A review of daytime ionosphere measurements made over New Mexico using a rocket-to-ground CW radio propagation method and a preliminary report of similar measurements made in the arctic ionosphere during a time of polar blackouts.

551.510.535:621.396.11 3715

On the Measurement of Virtual Height—I. Kay. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 11–14; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959).

551.510.535:621.396.11 3716

Interpretation of the Variation of Ionospheric Absorption as a Function of Frequency—K. Bibl, A. Paul and K. Rawer. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 949–952; February 16, 1959.) Errors in nondeviative absorption calculations are attributed to the presence in the E layer of a thin densely ionized E_s layer, The expression used earlier, (985 of 1952, Bibl and Rawer) has been revised. Results obtained using the new expression indicate that it allows a more detailed study of the absorption process.

551.510.535(98) 3717

Ionospheric Conditions in the Circumpolar Region—V. M. Driatski and A. S. Besprozvannaya. (*Ann. Géophys.*, vol. 14, pp. 438–455; October/December, 1958. In English.) A preliminary analysis of ionospheric and magnetic-field measurements made from a drifting observatory in the Arctic Ocean during the period May 15, 1954 to April 14, 1955. Values of 5–6 mc were obtained for f_0F_2 during the arctic night.

551.510.536 3718

Investigation of the Solid Component of Interplanetary Matter by means of Rockets and Artificial Earth Satellites—S. M. Poloskov and T. N. Nazarova. (*Uspekhi. Fiz. Nauk.*, vol. 63, pp. 253–265; September, 1957.) The kinetic energy of micrometeorites is measured by an acoustic method or by a new type of sensitive photomultiplier. Results of collisions of these particles with polished plates located on rockets are shown. Tables giving values of brightness, mass, radius and estimated fall out on the earth in 24 hours are included. Particles ejected from the sun and charged cosmic dust are also considered.

551.594.6 3719

A Preliminary Meteorological Study of the Origin of Whistlers—C. P. Mook. (*J. Geophys. Res.*, vol. 64, pp. 745–748; July, 1959.) "A possible unique source of whistling atmospherics is found to be the presence of large cyclonic disturbances at the geomagnetic conjugate point for the whistler receiving station. The possible role of these cyclonic disturbances in producing narrow magneto-ionic duct propagating conditions is also discussed."

LOCATION AND AIDS TO NAVIGATION

621.396.663 3720

The Reduction of Bearing Errors due to Multiple Incidence in Long-Base-Line Systems—F. Steiner and H. Stittgen. (*Nachrichtentech. Z.*, vol. 11, pp. 417–423; August, 1958.) The maximum bearing errors as a function of base length d/λ are calculated for the Adcock and Doppler systems. With increasing base line the errors decrease, the Adcock, but not the Doppler system, becoming more liable to ambiguities.

621.396.93(083.74) 3721

I.R.E. Standards on Navigation Aids: Direction-Finder Measurements, 1959—(PROC. IRE, vol. 47, pp. 1349–1371; August, 1959.) Standard 59 IRE 12. S1.

621.396.933.1 3722

Collision Detection without Range Data—Y. J. Liu and J. O. Campbell. (*Electronics*, vol. 32, pp. 60–63; July 24, 1959.) A system is developed which automatically computes the relative velocity vector of two aircraft and compares it with the line of sight. Warning is given if the two parameters are within a few degrees of one another.

621.396.933.23 3723

Blind Landing—W. J. Charnley. (*J. Inst. Nav.*, vol. 12, pp. 115–135; April, 1959. Discussion, pp. 135–140.) A detailed account of the B.L.E.U. system briefly described earlier (1892 of June) and a discussion of the principles of the "televiewer" manual blind landing system.

621.396.963.325:621.397.24 3724

Further Progress in Bandwidth Compression of Radar Displays—H. Meinke and A. Rihaczek. (*Nachrichtentech. Z.*, vol. 11, pp. 398–404; August, 1958.) By varying the scanning speed in a radar-signal storage system so that short pulses and intervals are lengthened at the expense of long pulses the bandwidth of the signal can be reduced. Transmission of radar PPI displays with 4-kc bandwidth over a telephone channel has been successful. See also 3744 of 1956 (Meinke and Groll).

621.396.969.3 3725

Checking Jitter in Moving-Target Radar—C. Clark. (*Electronics*, vol. 32, pp. 56–58; July 17, 1959.) A circuit is described for a unit which monitors the frequency of the coherent oscillator automatically, and provides a visible indication of the amount of jitter.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215:546.472.41 3726

Photoconductivity of Zinc Telluride—Y. Simon and J. Bok. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 2176–2178; April 13, 1959.) The conductivity of ZnTe prepared by fusion and subsequent recrystallization in hydrogen was observed in darkness and in visible light for fields up to 2000 v/cm. The enhanced conductivity at high field strengths can be attributed to shock ionization.

535.215:546.482.21 3727

A Lamination-Type Structure of CdS Crystals—H. Radelt. (*Naturwiss.*, vol. 45, p. 463; October, 1958.) Crystals grown from the vapor phase by Frerichs' method (450 of 1948) often exhibit a fine laminar structure. The effect is interpreted with reference to experimental investigations.

535.215:546.482.21 3728

Measurement of the Elastic Constants of CdS Single Crystals—E. Gutsche. (*Naturwiss.*, vol. 45, p. 566; December, 1958.) The results of mechanical tests on thin-plate and rod-shaped specimens are summarized. See also 3729.

535.215:546.482.21 3729

Compressibility and Pressure Displacement

of the Absorption Edge of Cadmium Sulphide—E. Gutsche. (*Naturwiss.*, vol. 45, p. 486; October, 1958.) Preliminary report of measurements on CdS single crystals at pressures up to 4000 kp/cm². The influence of hydrostat c pressure on the spectral distribution of photoconductivity is also investigated.

535.215:546.482.21 3730
Effect of Deformations on the Spectrum of CdS Crystals—E. F. Gross and B. S. Razbirin. (*Zh. Tekh. Fiz.*, vol. 28, pp. 237–239; February, 1959.)

535.215:546.482.21 3731
The Electrostatic Charging of CdS Single Crystals under the Influence of Strong Electric Fields—K. W. Böer and U. Kümmel. (*Ann. Phys.*, (*Lpz.*), vol. 2, pp. 217–224; November 11, 1958.) The results of measurements obtained cannot be interpreted by the theory of space-charge limitation (2566 of 1955, Smith and Rose), but they are in agreement with the assumption of inhomogeneous conductivity in CdS single crystals.

535.215:546.482.21 3732
Diffusion of Copper in Cadmium Sulphide Crystals—R. L. Clarke. (*J. Appl. Phys.*, vol. 30, pp. 957–960; July, 1959.) Diffusion coefficients determined using radioactive-tracer sectioning technique.

535.215:546.561–31 3733
Influence of Molecular Adsorption on the Longitudinal Photoconductivity of Cuprous Oxide—O. V. Snitko. (*Zh. Tekh. Fiz.*, vol. 28, pp. 35–44; January, 1958.) Report of an investigation on Cu_2O plates 0.2 mm thick coated on both sides with a semitransparent gold film and illuminated by 30-μsec light pulses in a glass container a) evacuated, and b) containing ethyl alcohol vapor.

535.215:546.561–31 3734
Time-lag of Photoeffect and Electrical Conductivity of Cuprous Oxide—A. L. Rvachev. (*Zh. Tekh. Fiz.*, vol. 28, pp. 45–51; January, 1958.) An oscillographic examination has been made of the photocurrents in Cu_2O samples with a) low and b) high specific conductance, under illumination by pulsed monochromatic light. Results show that the time-lag of the photoeffect depends not only on the wavelength of the incident light but also on the dark conductance. The spectral distribution of photosensitivity of different samples is shown and the method of preparation is described.

535.37 3735
The System ZnO.CdO.B_2O_3, Phase Relationships, and Fluorescence—D. E. Harrison and F. A. Hummel. (*J. Electrochem. Soc.*, vol. 106, pp. 24–26; January, 1959.) Two compounds have been isolated which, with Ma activator, give respectively orange and red fluorescence under cathode-ray excitation. See also 1778 of 1957.

535.37:546.472.21 3736
Activation of ZnS and (Zn, Cd)S Phosphors by Gold and other Elements—S. T. Henderson, P. W. Ranby and M. B. Halstead. (*J. Electrochem. Soc.*, vol. 106, pp. 27–34; January, 1959.) A study of spectral emission characteristics.

535.376 3737
Bimolecular Electroluminescent Transitions in GaP—E. E. Loebner and E. W. Poor, Jr. (*Phys. Rev. Lett.*, vol. 3, pp. 23–25; July 1, 1959.) A description of direct observations of bimolecular band-to-band transitions at rectifying junctions in single crystals of GaP and InP.

535.376:646.472.21 3738
Particle Size Effects and the Distribution of Barriers in Electroluminescent Zinc Sulphide Phosphors—P. Goldberg. (*J. Electrochem. Soc.*, vol. 106, pp. 34–38; January, 1959.) Particle size is shown to be a significant factor in empirical equations describing brightness/voltage relations.

537.226/.228 3739
Electromechanical Properties of Lead Titanate Zirconate Ceramics with Lead Partially replaced by Calcium or Strontium—F. Kulcsar. (*J. Amer. Ceram. Soc.*, vol. 42, pp. 49–51; January, 1959.) By partially substituting Sr for Pb, dielectric constants greater than 1300 can be obtained, with planar couplings of about 0.5. Ca also raises the dielectric constant but the planar coupling level is lower than with Sr.

537.227 3740
Contribution to the Theory of Domain Walls in Ferroelectrics—V. A. Zhirnov. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1175–1180; November, 1958.) Investigation of the transition region in 180° and 90° boundaries of ferroelectric domains in $BaTiO_3$. Expressions are derived for the thickness and surface energy of domain boundaries and some numerical estimates are made. The 180° domain boundary of Rochelle salt crystals is briefly discussed.

537.227 3741
Ferroelectric Properties of Colemanite—H. H. Wieder. (*J. Appl. Phys.*, vol. 30, pp. 1010–1018; July, 1959.)

537.227 3742
Polarization Reversal by Sideways Expansion of Domains in Ferroelectric Triglycine Sulphate—A. G. Chynoweth and J. L. Abel. (*J. Appl. Phys.*, vol. 30, pp. 1073–1080; July, 1959.) Experiments show that when fields are applied by liquid electrodes to crystals of triglycine sulphate, polarization is accomplished by the formation and sideways expansion of a few domains.

537.227:546.321.85–841 3743
Deuteron Magnetic Resonance Spectrum and Relaxation in KD_2PO_4—J. L. Bjorkstam and E. A. Uehling. (*Phys. Rev.*, vol. 114, pp. 961–968; May 15, 1959.)

537.227:546.431.824–31 3744
Dynamic Properties of the Polarizability in $BaTiO_3$ Crystal—K. Husimi. (*J. Appl. Phys.*, vol. 30, pp. 978–981; July, 1959.) "The second harmonic distortion by a $BaTiO_3$ crystal of a small high-frequency sinusoidal electric field, superimposed on a low-frequency switching field, is studied by the filter method. From the phase relationship of the second harmonic distortion with respect to the measuring signal, together with the increase of the fundamental component of the capacitive current, it is concluded that the polarizability increases markedly for the backward direction during switching."

537.227:546.431.824–31 3745
Investigation of the Temperature Dependence of Total Polarization, Coercive Force and Hysteresis Losses of (Ba, Sr) TiO_3, Ba(Ti, Sn)O_3 and Ba(Ti, Zr)O_3 Polycrystalline Solid Solutions—V. A. Bokov. (*Zh. Tekh. Fiz.*, vol. 28, pp. 77–86; January, 1958.) The spontaneous polarization of Ba(Ti,Sn)O_3 and Ba(Ti,Zr)O_3 decreases with decrease of $BaTiO_3$ content. In the solid solution (Ba,Sr)TiO_3 it decreases with increase of $SrTiO_3$ up to 40 per cent, but with $SrTiO_3$ content over 50 per cent a considerable increase in spontaneous polarization is observed.

537.228.1:546.482.21 3746
The Influence of the Activator and of the Storage of Radiation Energy on the Piezoelectric and Elastic Behaviour of Cadmium Sulphide Single Crystals—H. Gobrecht and A. Bartschat. (*Z. Phys.*, vol. 153, pp. 529–554; January 8, 1959.) Investigations were made at 20°C and −180°C to determine the temperature dependence of elastic damping for various degrees of activator concentration and the effects of crystal irradiation by light and infrared rays. See also 2278 of July.

537.311.3:538.569.4:539.2 3747
Energy Absorption by Charge Carriers of Negative Effective Mass in Crystals—C. Kittel. (*Proc. Nat. Acad. Science*, vol. 45, pp. 744–747; May, 1959.) A theoretical examination of the negative-resistance properties of a negative-carrier system.

537.311.33 3748
Solid-State Physics at N.B.S—(*Tech. Bull. Nat. Bur. Stand.*, vol. 43, pp. 92–96; May, 1959.) General account of semiconductor research in progress at the National Bureau of Standards.

537.311.33 3749
On the Theory of the Field Effect—V. L. Bonch-Bruevich. (*Zh. Tekh. Fiz.*, vol. 28, pp. 70–76; January, 1958.) A mathematical analysis of the effect of a transverse alternating field on semiconductor conductivity for any given values of Debye length and length of the free path.

537.311.33 3750
On the Influence of the Short-Range Order on the Type of Conductivity—V. L. Zyazev and O. A. Esin. (*Zh. Tekh. Fiz.*, vol. 28, pp. 18–22; January, 1958.) Measurements of conductivity of binary mixtures based on V_2O_5 for different temperatures and compositions are shown graphically. In V_2O_5—PbO, V_2O_5—CaO and V_2O_5—MgO the semiconductor mechanism is transformed into the ionic one when the concentration of the second component is low. This confirms Joffe's opinion on the character of conductivity.

537.311.33 3751
Remarks on Drift Velocity—Yu. N. Obraztsov. (*Zh. Tekh. Fiz.*, vol. 28, pp. 245–249; February, 1959.) Reasons are examined for the apparent difference in current density calculated using a) an exact solution of the kinetic equation and b) the drift velocity. Correct application of the latter method gives good results.

537.311.33 3752
Notes on the Theory of Semiconductors with an Excited Impurity Band—M. I. Klinger and G. A. Makarycheva. (*Zh. Tekh. Fiz.*, vol. 28, pp. 264–266; February, 1959.)

537.311.33 3753
Transport Phenomena in Nondegenerate Semiconductors Considering Electron-Electron Scattering—M. S. Sodha and Y. P. Varshni. (*Z. Phys.*, vol. 153, pp. 555–562; January 8, 1959. In English.) Hall mobility and other electron transport phenomena are investigated on *n*-type semiconductors in a magnetic field. Results are given for different impurity concentrations. See also 1225 of April (Sodha and Eastman).

537.311.33 3754
Transport Properties of Nondegenerate *n*-Type Semiconductors Considering Electron-Electron Scattering—M. S. Sodha and Y. P. Varshni. (*Phys. Rev.*, vol. 114, pp. 717–718; May 1, 1959.) Two proposed functions permit analytical integration of integrals appearing in

the theory of transport phenomena. (*e.g.* 3753).

537.311.33 3755
New Semiconducting Compounds—V. P. Zhuse, V. M. Sergeeva and E. L. Shtrum. (*Zh. Tekh. Fiz.*, vol. 38, pp. 233–236; February, 1959.) An investigation of $CuFeSe_2$, $CuFeTe_2$, $AgFeSe_2$ and $AgFeTe_2$. The temperature dependence of conductivity and Hall constant is shown for $AgFeTe_2$.

537.311.33 3756
Oxides which Show a Metal-to-Insulator Transition at the Néel Temperature—F. J. Morin. (*Phys. Rev. Lett.*, vol. 3, pp. 34–36; July 1, 1959.) Conductivity measurements on oxides of titanium and vanadium provide additional evidence for the existence of a conduction band of nonbonding orbitals. An explanatory model is suggested.

537.311.33:535.843.3 3757
Method of Rendering Visible the Conductivity Inhomogeneities of Semiconductors—K. W. Böer, H. J. Hänsch and U. Kümmel. (*Naturwiss.*, vol. 45, p. 460; October, 1958.) Preliminary report on tests carried out on CdS single crystals. Micrograms taken with monochromatic light show light and dark zones which indicate the field or current distribution inside the crystal.

537.311.33:537.32 3758
Investigation of Thermoelectric Properties of Bi_2Te_3–Bi_2So_3 Solid Solutions—G. N. Gordyakova, G. V. Kokosh and S. S. Sinani. (*Zh. Tekh. Fiz.*, vol. 28, pp. 3–17; January, 1958.) The effect of the addition of impurities to 80 per cent Bi_2Te_3 – 20 per cent Bi_2Se_3 solid solutions is examined. Best results are obtained with halides of the first group of elements or with copper. Results are tabulated and graphs show the temperature dependence of the electrical conductivity and the thermo-EMF for various impurity additions.

537.311.33:537.323 3759
$InAs_{1-x}P_x$ as a Thermoelectric Material—R. Bowers, J. E. Bauerle and A. J. Cornish. (*J. Appl. Phys.*, vol. 30, pp. 1050–1054; July, 1959.) Measurements of the electrical conductivity, the thermal conductivity, and the Seebeck coefficient have been made at high temperatures with x ranging from 0 to 0.4.

537.311.33:538.569.4 3760
Theory of Negative-Mass Cyclotron Resonance—D. C. Mattis and M. J. Stevenson. (*Phys. Rev. Lett.*, vol. 3, pp. 18–20; July 1, 1959.) It is shown that except under very restricted conditions, re-entrant states in Ge and Si will add a normal positive resistivity component to the material independently of their population.

537.311.33:539.23 3761
Vapour-Deposited Films of Semiconducting III–V Compounds—K. G. Günther. (*Naturwiss.*, vol. 45, pp. 415–416; September, 1958.) See 3349 of October.

537.311.33:546.23:537.533.8 3762
Measurements of Secondary Electron Emission from Selenium—G. Oertel. (*Ann. Phys.* (*Lpz*)., vol. 1, pp. 305–318; June 2, 1958.) A static and a dynamic method of measurement are used to determine the temperature dependence of secondary emission and the energy distribution of secondary electrons as a function of doping with Br and Te.

537.311.33:546.24 3763
The Band Structure of Tellurium—A. Pires de Carvalho. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 778–781; February 9, 1959.)

537.311.33:[546.28+546.289 3764
On the Distinction between Recombination Centres and Trapping Levels—V. L. Bonch-Bruevich. (*Zh. Tekh. Fiz.*, vol. 28, pp. 67–69; January, 1958.) This distinction which is examined for Ge and Si samples, does not appear to be of an absolute character but to depend on the properties of impurities, the temperature, the method of preparation of the sample and the condition of injection. Trapping levels seem most likely to occur near the middle of the forbidden zone.

537.311.33:[546.28+546.289 3765
On Reflection Coefficients of Germanium and Silicon Crystals—V. S. Vavilov, A. A. Gippins and M. M. Gorshkov. (*Zh. Tekh. Fiz.*, vol. 28, pp. 254–255; February, 1959.) A note on the optical properties of Ge and Si surfaces.

537.311.33:[546.28+546.289 3766
Reflecting Power of Bulk Silicon and Germanium between 1000 and 3000 Å—S. Robin-Kandare and B. Vodar. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 1965–1967; April 1, 1959.)

537.311.33:[546.28+546.289 3767
Growth of Large-Diameter Silicon and Germanium Crystals by the Teal-Little Method—W. R. Runyan. (*Rev. Sci. Instr.*, vol. 30, pp. 535–540; July, 1959.) The equipment and techniques used to grow crystals of 6 inch diameter are described, and the effect of spin, radiation, and mode of heating on crystal growth from a melt is discussed.

537.311.33:[546.28+546.289] 3768
Distribution of Slow Traps on the Surface of Germanium and Silicon with Reference to Relaxation Time—I. I. Abkevich. (*Dokl. Akad. Nauk SSSR.* vol. 127, pp. 1199–1202; August 21, 1959.) The time dependence of the contact potential after illumination of a freshly etched specimen and the time dependence of excess charges in slow surface traps are shown graphically. The capture of electrons in surface slow traps before illumination produces an electric field which lowers the barrier between traps and bulk of the sample decreasing the relaxation time of the traps.

537.311.33:546.28 3769
Lifetimes and Capture Cross-Sections in Gold-Doped Silicon—W. D. Davis. (*Phys. Rev.*, vol. 14, pp. 1006–1008; May 15, 1959.) The amplitude of the voltage pulses produced by α-particles was measured as a function of applied electric field, and the cross-sections for hole and electron capture at the gold sites deduced. The results were $2\times10^{-15}cm^2$ and $10^{-13}cm^2$ for neutral and oppositely charged sites respectively, for either holes or electrons.

537.311.33:546.28 3770
Microplasma Fluctuations in Silicon—K. S. Champlin. (*J. Appl. Phys.*, vol. 30, pp. 1039–1050; July, 1959.) The electrical properties of a fluctuating bistable microplasma are specified by three parameters which, in general, are functions of voltage. For an ideal low-impedance connection, these parameters are independent of time and thus yield simple forms for the pulse rate, average current differential conductance, and noise spectral density. With a high-impedance circuit the phenomenon is more complex, and only an approximate analysis is offered.

537.311.33:546.281.26:061.3 3771
Semiconducting Silicon Carbide—H. K. Henisch. (*Nature*, vol. 184, pp. 158–159; July 18, 1959.) Brief report of a conference held at Boston, Mass., April, 1959, to discuss the preparation, properties and applications of SiC.

537.311.33:546.289 3772
A New Study of the L-Spectrum of Germanium—A. Lucasson-Lemasson. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 1156–1158; February 23, 1959.)

537.311.33:546.289 3773
Influence of High-Energy Electron Bombardment on the Conductivity of Germanium—N. Van Dong, L. Koch, P. Baruch and P. Andre. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 788–791; February 9, 1959.) Report of an anomalous increase in the short-circuit current of a Ge junction when bombarded by high-energy electrons at 100°K. This effect may be explained by the Shockley-Read recombination theory if displacement of the Ferni level during bombardment is taken into account.

537.311.33:546.289 3774
Microwave Techniques in Measurement of Lifetime in Germanium—A. P. Ramsa, H. Jacobs and F. A. Brand. (*J. Appl. Phys.*, vol. 30, pp. 1054–1060; July, 1959.) "New techniques are proposed for the measurement of lifetime in semiconductors by utilizing the absorption of microwave power by charge carriers. The densities of holes and electrons are varied by irradiation with light or the conduction mechanism. Agreement is found when the microwave absorption methods are compared with the more established photoconductivity decay techniques. One of the new methods offers an advantage in that electrode attachments are no longer required."

537.311.33:546.289 3775
Electron-Spin-Resonance Experiments on Shallow Donors in Germanium—G. Feher, D. K. Wilson and E. A. Gere. (*Phys. Rev. Lett.*, vol. 3, pp. 25–28; July 1, 1959.) Resonances have been observed from both bound and nonlocalized electrons. Results indicate that the ground state of the As and P donors in Ge is a singlet.

537.311.33:546.289:537.32 3776
Volume Peltier Effect in Germanium—P. I. Baranskil. (*Zh. Tekh. Fiz.*, vol. 28, pp. 225–230; February, 1959.) A method is described for investigating the Peltier effect produced by imperfections in Ge single crystals. The current characteristic is linear and it is established that the measured thermo-EMF is a voluum gradient effect.

537.311.33:546.289:538.63 3777
Hot-Electron Behaviour in Germanium under the Influence of a Magnetic Field—L. Gold. (*Phys. Rev.*, vol. 114, pp. 691–704; May 1, 1959.) Theory developed using a model based on individual ellipsoidal energy surfaces is extended to investigate the anistropy existing with a superposed field.

537.311.33:546.47–31 3778
Surface Potential, Field-Effect Mobility, and Surface Conductivity of ZnO Crystals—H. J. Krusemeyer. (*Phys. Rev.*, vol. 114, pp. 655–664; May 1, 1959.)

537.311.33:546.49.241 3779
Some Properties of Mercuric Telluride—H. Fumeron-Rodot and M. Rodot. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 937–940; February 16, 1959.) A study of the thermomagnetic properties of specimens of HgTe with an electron mobility of $2.2\times10^4cm^2/v.sec$ at room temperature indicates that mobility is limited by collisions between electrons and acoustic phonons.

537.311.33:546.682.86 3780
Investigation of Thin Layers of Variable Composition in the Indium-Antimony System—G. A. Kurov and Z. G. Pinsker. (*Zh. Tekh.*

Fiz., vol. 28, pp. 29–34; January, 1958.) A metastable amorphous phase of Sb has been found in a mixture with crystalline particles of InSb in layers 1–2μ thick. In such layers, investigations have been made of a) the temperature dependence of conductivity, b) the abnormally low mobility of the charge carriers.

537.311.33:546.682.86 3781

Semiconductivity Experiments on Hot Electrons in InSb. Application to the Construction of an Oscillator—J. Bok and R. Veilex. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 2300–2302; April 20, 1959.) "Hot" carriers which have an energy sufficient to create new carriers occur when InSb is subjected to a strong electric field. Under pulse conditions at 77°K and in the presence of a longitudinal magnetic field of ~1200 oersteds, the upper part of the V/I characteristic has a negative slope. An oscillator based on this effect has been constructed, operating in the range 5–30 mc; it may be modified to give frequencies as high as 1200 mc. A second oscillation at low electric field strengths (~40 v/cm) was also observed.

537.311.33:546.682.86:535.215 3782

Photoanodization of InSb—J. D. Venables and R. M. Broudy. (*J. Appl. Phys.*, vol. 30, pp. 1110–1111; July, 1959.) It was observed that the InSb anodization process is sensitive to visible light of wavelength shorter than approximately 5200Å.

537.311.33:546.714–31 3783

Influence of Foreign Ions on the Semiconductivity of the Dioxides of Manganese—J. P. Chevillot and J. Brenet. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 776–778; February 9, 1959.) Measurements in the 20–80°C temperature range indicate that the influence of Th^{4+} ions in the lattice does not modify the intrinsic character but greatly diminishes the semiconductivity of both β-MnO_2 and γ-MnO_2.

537.311.33:546.817–31 3784

The Electrical Conductivity of Lead (II) Oxide with Additions of Higher-Valency Impurity Cations—H. Grunewald and W. Neumann. (*Ann. Phys.* (*Lpz.*), vol. 1, pp. 344–350; June 2, 1958.) Investigations were made on PbO with additions of Cr_2O_3, Nd_2O_3 and CeO_2 in the temperature range 200°C–500°C.

537.311.33:546.873.241 3785

Stoichiometry of Bismuth Telluride and Related Compounds—G. Offergeld and J. van Cakenberghe. (*Nature*, vol. 184, suppl. no. 4, pp. 185–186; July 18, 1959.)

537.311.33:548.5 3786

X-Ray Method for the Differentiation of {111} Surfaces in $A^{III}B^{V}$ Semiconducting Compounds—E. P. Warekois and P. H. Metzger. (*J. Appl. Phys.*, vol. 30, pp. 960–962; July, 1959.)

537.311.33:621.314.63 3787

Equilibrium Distribution of Field Potential and Concentration of Charge Carriers in Fused-In Junctions—E. I. Aditovich, Yu. S. Ryabinkin and K. V. Temko. (*Zh. Tekh. Fiz.*, vol. 28, pp. 55–66; January, 1958.) Mathematical analysis, based on a differential equation suggested by Shockley, for semiconductors with *p-n* or *p-i* junctions and in a state of thermodynamic equilibrium.

537.311.33:621.383.5 3788

Transient Response of Grain Boundaries and its Application for a Novel Light Sensor—R. K. Mueller. (*J. Appl. Phys.*, vol. 30, pp. 1004–1010; July, 1959.) The negative surface charge carried by grain boundaries in *n*-type Ge and Si constitutes a potential barrier for electrons, the height of which can be increased by applying an electrical pulse across the boundary or decreased by injecting holes. The relaxation time with which the perturbed barrier returns to its equilibrium value is, for sufficiently low temperatures, very large compared to the time necessary to change the barrier height. A theory of the transient response is given together with a description of a novel photosensor based on this phenomenon.

537.533.8:546.74 3789

Secondary Electron Emission from Nickel—A. R. Shul'man, I. R. Zakirova, Yu. A. Morozov and S. A. Fridrikhov. (*Zh. Tekh. Fiz.*, vol. 28, pp. 87–96; January, 1958.) An investigation of the energy distribution of secondary electrons emitted by Ni for primary electrons in the range 200–2000v. The number of secondary electrons with energies >100ev is >20 per cent.

538.22 3790

Magnetic Investigations on Pd mixed Crystals with Transition Elements—D. Gerstenberg. (*Ann. Phys.* (*Lpz*), vol. 2, pp. 236–262; November 11, 1958.) The results of susceptibility measurements in the temperature range 90°–1100°K are discussed.

538.22:538.569.4 3791

Antiferromagnetic Resonance in MnF_2—F. M. Johnson and A. H. Nethercot, Jr. (*Phys. Rev.*, vol. 114, pp. 705–716; May 1, 1959.) Report and discussion of the results of measurements in the frequency range 96–247.2 kmc from 4.2° to 64°K.

538.22:538.569.4:549.517.13 3792

Polarization of the Al^{27} Nuclei in Ruby—J. A. Cowen, W. R. Schafer and R. D. Spence. (*Phys. Rev. Lett.*, vol. 3, pp. 13–14; July 1, 1959.) Either enhanced absorption or strong emission is observed in components of the Al nuclear resonance by driving a microwave transition of the Cr impurity. Results can be explained in terms of a dynamic polarization process.

538.22:538.569.4:549.517.13 3793

Ruby as a Maser Material—C. Kikuchi, J. Lambe, G. Makhov, and R. W. Terhune. (*J. Appl. Phys.*, vol. 30, pp. 1061–1067; July, 1959.) "The reasons for the initial choice of ruby as a maser material are outlined and some measurements of the parameters in the spin Hamiltonian and of spin relaxation times are reported. The relative merits of single- and double-pump modes of operation of a four-level maser are discussed and measurements of the oscillator power for the two cases are included."

538.221 3794

The Influence of Carbon Inclusions on the Mobility of Bloch Walls—B. Rothenstein and J. Hrianca. (*Naturwiss.*, vol. 45, pp. 359–360; August, 1958.) Tests on iron wire show that Bloch-wall mobility increases with a reduction of carbon in solid solution.

538.221 3795

The Influence of Temperature on the Law of Distribution of Ferromagnetic Domains from the Point of View of Coercive Force—B. Rothenstein and J. Hrianca. (*Naturwiss.*, vol. 45, pp. 507–508; November, 1958.) Results of measurements on high-purity Ni specimens are discussed.

538.221 3796

Measurement of the Noise from Cyclic Remagnetization of Ferromagnetic Substances at Low Temperatures—N. N. Kolachevskiĭ. (*Zh. Eksp. Teor. Fiz.*, vol. 36, pp. 401–403; February, 1959.) An investigation in the temperature range 2 to 300°K revealed no dependence of noise on temperature.

538.221 3797

Magnetic Annealing in Perminvar: Part 1—Structural Origin—R. D. Heidenreich, E. A. Nesbitt and R. D. Burbank. (*J. Appl. Phys.*, vol. 30, pp. 995–1000; July, 1959.) A structural model is presented, based on an interpretation of electron-diffraction results, magnetic properties and oxygen content.

538.221 3798

Magnetic Annealing in Perminvar: Part 2—Magnetic Properties—E. A. Nesbitt and R. D. Heidenreich. (*J. Appl. Phys.*, vol. 30, pp. 1000–1003; July, 1959.) Faults form as a result of heat treatment in the temperature range at which magnetic annealing is effective. This is attributed to small amounts of oxygen as an impurity.

538.221:537.311.33 3799

Magnetic Properties of the System $Ni_{(1-x)}Li_xO$ between 80 and 300°K—N. Perakis, J. Wucher and G. Parravano. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 2306–2308; April 20, 1959.) Experimental results for $x=0.2$ and $x=0.3$ are discussed.

538.221:537.533.7 3800

Electron Mirror Microscopy of Magnetic Stray Fields on Grain Boundaries—L. Mayer. (*J. Appl. Phys.*, vol. 30, pp. 1101–1104; July, 1959.)

538.221:537.533.73 3801

Magnetic and Crystallographic Analysis by Electron Diffraction—S. Yamaguchi. (*Nuovo Cim.*, vol. 12, pp. 286–289; May 1, 1959. In English.) The diffraction patterns of a ferromagnetic specimen and of gold are superposed by a double-exposure technique and the diffraction-ring eccentricity is measured, from which the magnetization may be calculated.

538.221:538.569.4 3802

Magnetic Resonance of Polycrystalline Cobalt at 3,500 Mc/s as a Function of Temperature—G. Asch. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 781–784; February 9, 1959.) The resonance field is a maximum and the line width a minimum at 260°C. At this temperature the anisotropy energy is a minimum.

538.221:538.632 3803

Crystal Anisotropy and Magnetostriction with the Hall Effect in Ferromagnetic Materials—W. Jellinghaus and M. P. de Andrés. (*Naturwiss.*, vol. 45, p. 508; November, 1958.) Hall-effect measurements on 3.3 per cent-Si laminations indicate the anisotropy of carrier mobility in ferromagnetic crystals. The effect of elastic tension in the direction of current flow on the magnitude of the magnetization-dependent Hall effect is investigated for four different materials.

538.221:539.23 3804

The Magnetic Properties of Electrolytically Produced Thin Nickel Films—W. Ruske. (*Ann. Phys.*, (*Lpz.*), vol. 2, pp. 274–286; November 11, 1958.) Hysteresis loops were obtained for the thickness range 20–20,000Å to determine the dependence of magnetic properties on film thickness and structure, and on treatment.

538.221:539.23 3805

The Temperature Dependence of the Electrical Resistance of Nickel-Copper and Nickel-Chromium Alloys and of Thin Nickel and Palladium Vapour-Deposited Films, the Ferromagnetic Resistance Anomaly and the Curie Temperature—H. J. Bauer. (*Z. Phys.*, vol. 153, pp. 484–507; December 22, 1958.)

538.221:621.318.124 3806

On the Variation of Magnetization of Uniaxial Substances as a Function of the Field; Application to $6Fe_2O_3.BaO$—V. S. Giron and

R. Pauthenet. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 943–946; February 16, 1959.) A graphical method is described for determining magnetization curves for all values of field.

538.221:621.318.124:537.226 3807
Anisotropy of the Dielectric Properties of Oriented Barium Ferrite—J. Rupprecht and C. Heck. (*Naturwiss.*, vol. 45, p. 511; November, 1958.) Preliminary report on measurements of dielectric constant and loss factor as a function of frequency in the range 60 kc–30 mc.

538.221:621.318.134 3808
Effect of a Small Proportion of Cobalt on the Magnetic Dispersion of Nickel-Zinc Ferrites—A. Marais. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 2303–2305; April 20, 1959.)

538.221:621.318.134 3809
Geometrical Anisotropy of Magnetic Materials in Waveguides and Cavities—L. A. Steinert. (*J. Appl. Phys.*, vol. 30, p. 1109; July, 1959.) A general derivation for the effective susceptibilities of ellipsoidal isotropic ferrite samples in uniform magnetic fields.

538.221:621.318.134:538.569.4 3810
Ferrite Line Width Measurements in a Cross-Guide Coupler—D. C. Stinson. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 446–450; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

538.221:621.318.134:538.569.4 3811
Effects of Rare-Earth Impurities on Ferrimagnetic Resonance in Yttrium Iron Garnet—J. F. Dillon, Jr., and J. W. Nielsen. (*Phys. Rev. Lett.*, vol. 3, pp. 30–31; July 1, 1959.) Experimental data are given for several rare-earth-doped crystals.

538.221:621.318.134:538.569.4 3812
Low-Temperature Line-Width Maximum in Yttrium Iron Garnet—E. G. Spencer, R. C. LeCraw and A. M. Clogston. (*Phys. Rev. Lett.*, vol. 3, pp. 32–33; July 1, 1959.)

538.221:621.318.134:538.569.4 3813
Identification of the Magnetostatic Modes of Ferrimagnetic Resonant Spheres—P. Fletcher, I. H. Solt, Jr., and R. Bell. (*Phys. Rev.*, vol. 114, pp. 739–745; May 1, 1959.) A detailed comparison between the magnetostatic theory and experimental observation.

538.221:621.318.134:538.569.4.08 3814
Direct Measurement of the Width of the Resonance Curves of Ferromagnetic Materials—R. Vautier and A. J. Berteaud. (*Compt. rend. Acad. Sci., Paris.*, vol. 248, pp. 1957–1959; April 1, 1959.) A simple method is described for determining ΔH from cavity measurements without plotting the complete absorption/field-strength curve. Its application to Y-Fe garnet is noted.

538.221:621.318.134:621.317.3 3815
Investigation of the Properties of Ferrites at Radio Frequencies—I. Teodorescu. (*Telecommunicatii*, vol. 2, pp. 108–113; May/June, 1958.) An experimental method for measurements in very weak RF fields is described. Certain phenomena not observed by other methods are noted.

538.569.4:534.133–8 3816
Effects of 9.2-kMc/s Ultrasonics on Electron Spin Resonances in Quartz—E. H. Jacobsen, N. S. Shiren and E. B. Tucker. (*Phys. Rev. Lett.*, vol. 3, pp. 81–83; July 15, 1959.) The electron-spin-resonance signal is observed as a function of the power and frequency of the ultrasonic vibrations and of the spectrometer power.

538.569.4:534.14–8 3817
Excitation of Hypersonic Waves by Ferromagnetic Resonance—H. Bömmel and K. Dransfeld. (*Phys. Rev. Lett.*, vol. 3, pp. 83–84; July 15, 1959.) The experimental arrangement for observing waves emitted from a Ni film deposited on a quartz surface is described. The excitation mechanism in this and other cases is considered.

621.315.616 3818
Investigation of the Temperature Dependence of Dielectric Losses and Permittivity of Polymers in the Centimetre Range ($\lambda = 3.3 - 10$ cm): Parts 1 and 2—G. P. Mikhaĭlov and A. M. Lobanov. (*Zh. Tekh. Fiz.*, vol. 28, pp. 267–278; February, 1959.) Report of measurements made in the temperature range $-100°$ to $+200°$C using a short-circuited waveguide with the sample located at the short circuit.

MEASUREMENTS AND TEST GEAR

621.317.337:621.372.413 3819
Microwave Q Measurements in the Presence of Coupling Losses—E. L. Ginzton. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-6, pp. 383–389; October, 1958. Abstract, PROC. IRE, vol. 47, pp. 112–113; January, 1959.)

621.317.34:621.372.21 3820
Measuring the Capacitance per Unit Length of Two Infinite Cones of Arbitrary Cross Section—J. D. Dyson. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 102–103; January, 1959. Abstract, PROC. IRE, vol. 47, p. 611; April, 1959.)

621.317.34:621.372.832.43 3821
A Method for Measuring the Directivity of Directional Couplers—G. E. Schafer and R. W. Beatty. (IRE TRANS. ON MICROWAVE THEORY AND PROPAGATION, vol. MTT-6, pp. 419–422; October, 1958. Abstract, PROC. IRE, vol. 47, p. 113; January, 1959.)

621.317.34:621.372.852.4 3822
Equipment for the Investigation of Polarization Properties of Transmission Elements in the 4-Gc/s Region—Baur. (*See* 3564.)

621.317.4:538.7:538.569.4 3823
Measurement of the Terrestrial Magnetic Field by means of a Nuclear-Resonance Maser—H. Benoit and J. Hennequin. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 1991–1993; April 1, 1959.) Experiments on the measurement of a field modified by an electromagnet are described and show that the weak-field maser (2548 of August, Benoit *et al.*) may be useful for measuring the geomagnetic field.

621.317.42:538.569.4 3824
High-Precision Measurement of the Average Value of a Magnetic Field over an Extended Path in Space—C. Sherman. (*Rev. Sci. Instr.*, vol. 30, pp. 568–575; July, 1959.) A nuclear-magnetic-resonance technique is used to measure the change in excitation of nuclei contained in a liquid flowing through the space under investigation.

621.317.729.1 3825
Anisotropic Field Plotting in the Electrolytic Tank—D. A. Jones. (*Rev. Sci. Instr.*, vol. 30, pp. 577–578; July, 1959.) Anisotropic field problems are simulated in an electrolytic tank by varying the resistance to motion of the electrolyte along two axes.

621.317.75:681.142 3826
Statistical Analysis of Noise-Signal Amplitudes—D. Hoffman and E. Schutzman. (*Electronics*, vol. 32, pp. 48–49; July 24, 1959.) A system is described which provides digital data from which the amplitude probability distribution and the probability density functions can be plotted.

621.317.755 3827
The Use of Pre-pulse Techniques in High-Speed Oscillography—F. E. Whiteway. (*J. Brit. IRE*, vol. 19, pp. 439–449; July, 1959.) The frequency range of conventional oscilloscopes and associated amplifiers can be extended by switching into a high-current operating condition for a very short part of the duty cycle. Pre-pulse time bases and generators are discussed and a four-valve amplifier with 140-mc bandwidth and a gain of 360 is described.

621.317.755 3828
Sample Method displays Millimicrosecond Pulses—W. E. Bushor. (*Electronics*, vol. 32, pp. 69–71; July 31, 1959.) Circuit details of an oscilloscope capable of displaying pulses of rise time 0.4 mμs. The sensitivity achieved is better than 3 mv/cm.

621.317.78.029.62 3829
Measurement of Pulsed Powers at Metre Wavelengths—A. Dumont and H. d'Hoop. (*Rev. HF, Brussels*, vol. 4, No. 5, pp. 119–123; 1959.) A description of a direct-reading transistorized peak voltmeter for the measurement of incident and reflected power. The instrument is calibrated from a calorimetric measure of the HF pulse power developed in an oil-cooled load.

631.317.794 3830
Microwave Power Detectors—R. Stata. (*Electronics*, vol. 32, p. 59; July 17, 1959.) Two tables summarize the basic characteristics of crystal rectifiers, barretters, and thermistors for the detection or measurementof microwave power.

621.317.794 3831
Designing a Power Density Meter—A. Borck. (*Electronics*, vol. 32, pp. 66–69; July 17, 1959.) Discussion of dipole and horn probes, attenuators and detectors for measurements in the near-field zone of high-power microwave transmitting antennas.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

537.533.35(091) 3832
Electron Microscopy—E. Ruska. (*VDI Z.*, vol. 101, pp. 1106–1109; August 11, 1959.) A review covering developments since 1957. 56 references. See also 1512 of 1958.

537.54:629.1.03 3833
Plasma Engine Verifies Theory—(*Electronics*, vol. 32, pp. 86–89; July 31, 1959.) A machine has been constructed consisting of two electrodes, one opened into a nozzle, and based on the magnetic acceleration of a plasma or pinch-effect principle to obtain thrust. The performance of such a machine in a space vehicle is discussed.

616:621.3.083.7:621.314.7 3834
The Ingestible Intestinal Transmitter for Signalling pH Values—M. von Ardenne and H. B. Sprung. (*Naturwiss.*, vol. 45, pp. 564–565; December, 1958.) The transmitter, which is 28 mm long and 8 mm in diameter, operates at 1.9 mc; this frequency increases linearly with pH value with a maximum rise of 13 kc corresponding to 8.5 pH units. See also 1327 of April.

621.384.61 3835
Cyclic Motion of Charged Particles in an Electric Field—A. A. Kolomenskiĭ and Fan Shou-syan'. (*Zh. Eksp. Teor. Fiz.*, vol. 36, pp.

271–276; January, 1959.) A mathematical treatment of particle trajectories in a system of strong- or weak-focusing lenses. Resonance acceleration of the particles and their phase stability are considered. The effect of em radiation on the motion of electrons is examined.

621.384.622.2 3836
The Multifactor Effect in a Linear Electron Accelerator—V. J. Vanhuyse, J. L. Veshaeghe and J. Turf. (*Nuovo Cim.*, vol. 10, pp. 721–727; November 16, 1958. In English.) More detailed treatment of the effect reported earlier (1329 of April, Vanhuyse).

621.384.612 3837
On the Maximal Energy and Intensity of the Electrons Accelerated by the Microtron—F. Porreca. (*Nuovo Cim.*, vol. 11, pp. 283–286; January 16, 1959. In English.)

621.385.833 3838
Spherical Aberration in Weakly Convergent Magnetic Lenses—P. Durandeau, B. Fagot and C. Fert. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 946–949; February 16, 1959.) The coefficient of spherical aberration is given for a series of thin magnetic lenses both symmetrical and asymmetrical.

629.19.053:621.375.4 3839
Guidance Systems in Manned Space Flight—S. T. Cap and N. P. White. (*Electronics.*, vol. 32, pp. 49–51; August 14, 1959.) A description of a complete inertial guidance system is given, with details of the transistorized amplifiers in the integrating circuits. Ten Si transistors are used to give a gain of 250000. Error in computation due to the amplifier is less than 0.01 per cent. Negative feedback is applied over each stage.

PROPAGATION OF WAVES

621.396.11 3840
On Statistic Theory of Radio Wave Propagation over an Ideally Conducting Plane—E. A. Kaner and F. G Bass. (*Dokl. Akad. Nauk. SSSR*, vol. 27, pp. 792–795; August 1, 1959.) Computation of statistical characteristics of the em field propagating in a medium with small random fluctuations of permittivity over an ideally conducting half space, the medium above the dividing surface being statistically uniform.

621.396.11 3841
Propagation of Radio Waves along an Inhomogeneous Surface—E. L. Feinberg. (*Nuovo Cim.*, vol. 11, suppl. 1, pp. 60–91; 1959. In English.) From a study of classical theory a fundamental integral equation for a field at the earth's surface is derived. The equation is used as a basis for the development of formulas relevant to propagation over a flat or a spherical earth with homogeneous or inhomogeneous surfaces. Results for inhomogeneous paths are compared with those obtained by semi-empirical methods. An application of the theory was described by Boudouris (236 of 1958.)

621.396.11 3842
Propagation of a Ground-Wave Pulse around a Finitely Conducting Spherical Earth from a Damped Sinuisoidal Source Current—J. R. Johler and L. C. Walters. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 1–10; January, 1959. Abstract, PROC. IRE, vol. 47, pp. 609–610; April, 1959.)

621.396.11 3843
Back-Scattering Measurements with a Space-Separation Method—H. J. Schmitt. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 15–22; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.11 3844
Scattering of a Surface Wave by a Discontinuity in Reactance—A. F. Kay. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 22–31; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.11:550.389.2:629.19 3845
Refraction of Very-High-Frequency Radio Signals at Ionospheric Heights—Weisbrod and Colin. (*See* 3698.)

621.396.11:551.510.52 3846
Theoretical Research on Tropospheric Scatter Propagation in the United States, 1954–1957—H. Staras and A. D. Wheelon, (IRE TRANS. ON ANTENNAS AND PROPAGATION. vol. AP-7, pp. 80–87; January, 1959. Abstract, PROC. IRE, vol. 47, p. 610; April, 1959.)

621.396.11:551.510.535 3847
Nonlinear Interaction of Radio Waves Propagating in a Plasma—V. L. Ginzburg. (*Zh. Eksp. Teor. Fiz.*, vol. 35, pp. 1573–1575; December, 1958.) Mathematical note on nonlinear effects in the interaction of radio waves in the ionosphere: a) the usual "quadratic" effect, giving rise to combination frequencies $\omega' \pm 2\omega$, where ω' is the frequency of a weak signal propagated in a medium which is perturbed by a strong wave at frequency ω; b) effects similar to those occurring in the scattering of transverse waves on plasma waves in an isotropic medium (see *e.g.* 3047 of 1958, Akhiezer *et al.*), which give rise to combination frequencies $\omega' \pm \omega$.

621.396.11:551.510.535 3848
New Geometrical Properties and their Usefulness for Ionospheric Radio Propagation—K. Toman. (PROC. IRE, vol. 47, pp. 1381–1382; August, 1959.) The geometrical properties dealt with concern the intercept which a straight line passing through a fixed point P makes between two concentric circles. If absorption of a signal reaching the earth from a satellite is proportional to the length of this intercept, the thickness of the absorbing layer can then be calculated. Other consequences of the geometry are discussed.

621.396.11:551.510.535:550.38 3849
The Geometry of the Earth's Magnetic Field at Ionospheric Heights—G. H. Millman. (*J. Geophys. Res.*, vol. 64, pp. 717–726; July, 1959.) Assuming the earth's magnetic field to be approximated by a centred magnetic dipole, the technique of matrix-coordinate transformations is used to develop a method for determining the angle between the earth's magnetic field and the direction of propagation of a radio wave for any geographic location and azimuth and elevation angle of transmission.

621.396.11.029.62 3850
Particularities of Ultra-Short-Wave Propagation in Towns—G. Ionescu. (*Telecomunicatii*, vol. 2, pp. 128–137; May/June, 1958.) Note of measurements made in Bucharest to determine field-strength contours at frequencies of 50, 70 and 100 mc. The minimum transmitter power for television or FM coverage is calculated with reference to the mean noise level.

STATIONS AND COMMUNICATION SYSTEMS

621.376.3/.4 3851
Power in an Angle-Modulated Wave—W. C. Vaughan. (*Electronic Radio Eng.*, vol. 36, pp. 289–291; August, 1959.) Two mathematical proofs are given which confirm that a negligible amount of power is required to modulate the angle of a sinusoidal carrier by a sinusoidal signal.

621.391 3852
The Fundamental Theorems of Information Theory Particularly in Telecommunications—H. Wolter. (*Arch. elekt. Übertragung*, vol. 12, pp. 335–345; August, 1958.) An ambiguity in the proof of Shannon's sampling theorem and the contradictions involved in the assumption of sharp frequency limits are discussed. An equation is derived for determining the time function at the input of a communication channel of given bandwidth from the time function measured at the output. Electronic computer circuits are described which solve this equation automatically and can therefore effectively expand the channel bandwidth to any desired value.

621.391 3853
A Physical Interpretation of Shannon's Ambiguity—J. Loeb. (*Ann. Télécommun.*, vol. 13, pp. 78–82; March/April, 1958.) The Shannon "ambiguity" (1361 of 1949) is interpreted, for the case of Gaussian noise superposed on an AM signal, by a transitional probabilities matrix ("grille"). This method can also be applied to problems involving non-Gaussian noise or nonlinear circuit elements.

621.391:534.75 3854
Definitions of d' and η as Psychophysical Measures—W. P. Tanner, Jr., and T. G. Birdsall. (*J. Acoust. Soc. Amer.*, vol. 30, pp. 922–928; October, 1958.) The theory of signal detectability is reviewed to clarify the definitions of d' and η. The efficiency η is defined as the ratio of the energy required by an ideal receiver to the energy required by a receiver under study when the performance of the two is the same. The measure d' is that value of $(2E/N_0)^{\frac{1}{2}}$ necessary for the ideal receiver to match the performance of the receiver under study, where E is the energy of the signal and N_0 the noise power per unit bandwidth. The measure is extended to include the recognizability of two signals. Every set of signals is described by a Euclidean space in which distances are the square roots of the energy of the difference signal.

621.391:621.376.56 3855
Speech Transmission with Quantization in Few Stages—K. Küpfmüller and W. Andrich. (*Nachrichtentech. Z.*, vol. 11, pp. 389–392; August, 1958.) The optimum number and value of threshold levels on which quantization is based is determined experimentally. Four threshold levels are adequate for useful intelligibility.

621.395.741:621.3.018.78 3856
A Contribution to the Law of Addition of Distortion Voltages in Long-Distance Communication Systems with Amplitude Modulation—H. Zuhrt. (*Nachrichtentech. Z.*, vol. 11, pp. 424–428; August, 1958.) A numerical method of solving the formula derived by Steinbuch and Marko (2421 of 1955) is given; results obtained are better than those of the graphical method especially for systems with many repeaters.

621.396.5:534.76:621.396.82 3857
F.M. Multiplex Spectra and Interference—L. B. Arguimbau. (PROC. IRE, vol. 47, pp. 1372–1373; August, 1959.) Experiment shows that the theoretical widening of the transmitted spectrum brought about by the use of a subcarrier for stereophony has little effect on adjacent or alternate-channel interference.

621.396.65:621.396.812.3 3858
Statistics of the Fading-Dependent Noise Power for Wide-Band Radio Links with Many Sections—W. Hormuth. (*Arch. elekt. Übertragung*, vol. 12, pp. 346–356; August, 1958.) The C.C.I.R. reference circuit for wide-band radio links is considered and assumed to be divided into 45 sections of 55.6 km. Other assumptions include continental propagation conditions and

FM operation in the range 1–8 kmc. The received noise power is calculated for Rayleigh distribution of fading over the whole or part of the path, the rest of the sections being affected by fading of Gaussian distribution. A fading margin of 5 db per section is considered adequate. Theoretical results are compared with practical observations.

621.396.932 3859

Mobile Maritime Service—R. Gea Sacasa. (*Rev. Telecommun.* (*Madrid*), vol. 13, pp. 19–23; March, 1959.) Signal strength measurements at Cadiz of ship's transmissions at 4, 6, 8, 12 and 16 mc along the route Centa (Spanish Morocco)—Sidon (Lebanon) are analyzed with reference to forecasts by the Gea method (see *e.g.* 1339 of April).

621.396.934:621.398 3860

Some Notes on Space Communications—J. P. Costas. (Proc. IRE, vol. 47, pp. 1383–1385; August, 1959.) An analysis of telemetry systems is given; it is suggested that parallel data transmission (as in frequency-division multiplex) will be inferior to serial data transmission in space communication.

SUBSIDIARY APPARATUS

621–52(047.1) 3861

Control Techniques—E. Krochmann. (*VDIZ.*, vol. 101, pp. 835–844; July 11, 1959.) Annual review covering investigations of control problems, methods of control, and regulating equipment. 209 references.

621.311.6:629.19 3862

Silicon Solar Batteries as a Source of Electrical Supply in Artificial Earth Satellites—V. S. Vavilov, V. M. Malovetskaya, G. N. Galkin and A. P. Landsman. (*Usp. Fiz. Nauk*, vol. 63, pp. 123–129; September, 1957.) Experiments using Si *p-n* junctions to convert solar radiation into electrical energy are described. Photoelements having a surface area of 5–8 cm² and a thickness of 0.7–1.0 mm were used. At sea level with the sun rays incident normally, an efficiency of 11 per cent was recorded corresponding to 100 w for an area of 1 m². With a solar constant of 0.135 w/cm², a Si plate exposed to the sun rays showed a temperature of 324° K.

621.314.63 3863

Breakdown of Silicon Power Rectifiers—M. A. Weston. (*Electronic Radio Eng.*, vol. 36, p. 313; August, 1959.) A description of a type of breakdown which can occur when Si junction rectifiers are used in series to rectify a high-frequency hv supply (700 v, 2400 cps). The cause was traced to minority-carrier storage effects and methods of overcoming it are described.

621.316.721.078:621.385.3 3864

Elimination of the Effect of Thermal Delay of the Cathode on a Valve with Grid Compensation—Y. Descamps. (*Compt. rend. Acad. Sci., Paris*, vol. 248, pp. 2076–2078; April 6, 1959.) The circuit described earlier (1369 of May, Curie and Descamps) is adapted for the compensation of transient fluctuations by means of an *RC* network which delays the application of the compensating voltage to the grid.

621.352 3865

Magnesium-Bismuth Oxide Dry Cells—C. K. Morehouse and R. Glicksman. (*J. Electrochem. Soc.*, vol. 106, pp. 61–63; January, 1959.) The cell construction and its performance characteristics are described. After an initial voltage drop, cells have a flat voltage discharge curve slightly above 1 v.

621.352 3866

Zinc-Mercuric Dioxysulphate Dry Cell—S. Ruben. (*J. Electrochem. Soc.*, vol. 106, pp. 77–78; February, 1959.) A cell is described which has the desirable characteristics of the mercuric oxide alkaline cell, the conventional construction of the dry cell and a relatively flat discharge characteristic at 1.3 v for loads within the rated current density.

TELEVISION AND PHOTOTELEGRAPHY

621.397.5:621.395.625.3 3867

Video Time-Delay Systems for International Television Program Exchange—R. H. Snyder. (*J. Soc. Mot. Pic. Telev. Eng.*, vol. 68, pp. 135–136; March, 1959.) A general discussion of the use of tape recorders for the conversion of line and frame standards and for storing program material, with some details of the Ampex video tape recorder.

621.397.61:621.396.677 3868

Transmitting Antennas for Television Broadcasting in the United Kingdom—Brown. (*See* 3571.)

621.397.61.004.5 3869

The Monitoring of Television Transmission Systems and Omnidirectional Transmitters—O. Macek. (*Elektrotech. u. Maschinenb.*, vol. 76, pp. 321–327; July 1, 1959.) See also 2763 of August.

621.397.621:621.314.7 3870

Transistorized Horizontal Deflection for Television—M. Fischman. (*Electronics*, vol. 32, pp. 60–63; August 14, 1959.) A 90° horizontal deflection circuit and high-voltage generator using only two transistors and a diode is described.

621.397.621.2 3871

Improvements in Television Receivers: Part 6a—Design Considerations for Stabilized Line Output Circuits—D. Hoogmoed, A. Boekhorst and H. Heyligers. (*Electronic Applic.*, vol. 19, pp. 15–24; March, 1959.) An addendum to 3124 of September (Dammers *et al.*) giving a simplification of the procedure for plotting a combined nomogram and short notes on the influence of the beam current and the validity of the formula for anode dissipation of the line output tube.

TRANSMISSION

621.376.3:621.396.61 3872

A Frequency Modulator for Broadcasting Transmitters utilizing Overall Negative Feedback—E. L. C. White. (*Proc. IEE* (London), Part B, vol. 106, pp. 408–416; July, 1959.) Existing techniques are reviewed and compared with the feedback method. A system using the latter method is described in detail.

621.396.61 3873

A New Very-Low-Frequency C.W. Transmitter for Ionospheric Investigation—KM2XIX—R. M. Golden, R. V. Langmuir, R. S. Macmillan and W. V. T. Rusch. (Proc. IRE, vol. 47, p. 1381; August, 1959.) An 8-mile section of a power transmission line is used as an antenna at 4–40 kc.

TUBES AND THERMIONICS

621.314.63:546.817.221 3874

Study of Current/Voltage Characteristics of n-p Contacts on Galena—P. V. Khandekar and J. N. Das. (*Curr. Sci.*, vol. 26, pp. 386–387; December, 1957.) Earlier investigations (2560 of 1956, Bhide *et al.*) have been extended using an *n*-type crystal of PbS as a whisker contact on *p*-type material. The observed i/v characteristics, excluding the saturation region in the forward direction, are due to the *n-p* contact, and are in close agreement with theory for values of contact potential difference $\lesssim 0.25$ v.

621.314.63:621.373.029.65 3875

Experiment indicating Generation of Submillimetre Waves by an Avalanching Semiconductor—A. Schleimann-Jensen. (Proc. IRE, vol. 47, pp. 1376–1378; August, 1959.) An embankment of semiconducting material was formed on an anode of low-melting-point metal by creating a corona discharge between it and a needle cathode 1μ distant. Eventually a steady current passes between anode and cathode, but this is subject to sudden jumps at certain voltages. This is believed to be associated with avalanche breakdown in the semiconductor and evidence is given that waves of wavelength 100μ are generated. For further notes see *Ibid.*, pp. 1378–1379.

621.314.63:621.396.822 3876

An Investigation of the Properties of Germanium Mixer Crystals at Low Temperatures—L. K. Anderson and A. Hendry. (IRE. Trans. on Microwave Theory and Techniques, vol. MTT-6, pp. 393–398; October, 1958. Abstract, Proc. IRE, vol. 47, p. 113; January, 1959.)

621.314.63.029.6 3877

Recent Developments in Microwave Diodes—E. J. Feldman. (*Sylvania Tech.*, vol. 11, pp. 71–75; April, 1958.) Specifications of several new crystal diodes are discussed including reversible-polarity and wide-band tripolar types.

621.314.7 3878

An Investigation of the Dependence of the Current Gain of a Plane-Alloy-Junction Transistor on Emitter Current and Frequency—F. J. Hyde. (*Proc. IEE* (London), Part B, vol. 106, pp. 391–396; July, 1959.) "The complex internal current gain, α_d, of a diffusion-type germanium transistor has been derived from measurements of the external short-circuit current gain, α, at frequencies up to 20 Mc/s and for emitter currents between 15μA and 3 mA, by taking account of the effects of the emitter and collector depletion-layer capacitances and the ohmic base resistance. The resulting frequency dependence of α_d is that expected from unidimensional diffusion theory. At low emitter currents, the flow of r.f. current in the emitter depletion-layer capacitance causes the cut-off frequency of α to be less than one-third that of α_d."

621.314.7 3879

Drift Transistors—J. te Winkel. (*Electronic Radio Eng.*, vol. 36, pp. 280–288; August, 1959.) A development of equivalent circuits for drift transistors including approximations appropriate to limited frequency ranges and large values of the drift field. The resulting circuits are similar to those for alloy transistors.

621.314.7 3880

An Investigation of the Current Gain of a Drift Transistor at Frequencies up to 105 Mc/s—F. J. Hyde. (*Proc. IEE* (London), Part B, vol. 106, pp. 397–404; July, 1959.) A description of measurements of the complex internal short-circuit current gain of a Type-2N247 plane alloy-junction Ge transistor over a range of emitter current from 50 μa to 8 ma. The results are interpreted in terms of Kroemer's theoretical treatment based on the existence of a uniform drift field across the base.

621.314.7 3881

High-Frequency Power Gain of the Drift Transistor—F. J. Hyde. (*Proc. IEE* (London), Part B, vol. 106, pp. 405–407; July, 1959.) "Approximate expressions are derived for (*a*) the critical frequency above which the ideal transistor is unconditionally stable, and (*b*) the resulting maximum available gain, for the common-emitter configuration. These involve the internal cutoff frequency, the low-frequency emitter input conductance, the ohmic base

resistance and the emitter and collector depletion-layer capacitances."

621.314.7:546.289 3882
Calculation of the Dependence of the Current Amplification Factor on the Emitter Current in Germanium Transistors for Injection and Extraction at High Temperatures—L. L. Makovskiĭ. (*Zh. Tekh. Fiz.*, vol. 28, pp. 52–54; January, 1958.) A theoretical interpretation of experimental results (599 of 1957, Stafeer *et al.*) showing that in Ge transistors the dependence of the current amplification factor on the emitter current is different at room temperature and at 90°C.

621.314.7:621.318.57 3883
Two-Terminal p-n-p-n Switches—J. M. Goldey. (*Bell Labs. Rec.*, vol. 37, pp. 223–226; June, 1959.) A note on the preparation of Si *p-n-p-n* transistors and their operation as regenerative-type switches.

621.383:535.376:621.375.9 3884
Lumistors: Amplifiers of the Future—C. F. Spitzer. (*Electronic Equipm. Engng.*, vol. 7, pp. 34–38; February, 1959.) An electroluminescent cell and a photoconductor have been combined into a device which will operate as an amplifier with a power gain of 40 db. Applications are suggested.

621.383.5:621.3.011.4 3885
Use of Surface-Barrier Photodiodes as Fast-Response Photocapacitors—E. Ahlstrom, W. G. Matthei and W. W. Gärtner. (*Rev. Sci. Instr.*, vol. 30, pp. 586–590; July, 1959.) The capacitance of a surface-barrier photo-diode comprising a gold film on *n*-type Si is plotted as a function of light intensity for different values of bias voltage and series resistance. An analysis to be published shows that the overall time constant may be reduced to millimicroseconds and further. Applications to photodetection using the parametric-amplifier principle are noted.

621.385.029.6 3886
Paraxial Formulation of the Equations of Electrostatic Space-Charge Flow—P. T. Kirstein. (*J. Appl. Phys.*, vol. 30, pp. 967–975; July, 1959.) Presents detailed analysis for beams from a space-charged-limited cathode in the form of a cone. The agreement between the paraxial theory and the exact theory for particular beams is investigated.

621.385.029.6 3887
Improving Microwave Tube Efficiency—D. Walsh. (*Electronics*, vol. 32, pp. 70–73; July 17, 1959.) Electron beams of that elliptical cross-section required by some microwave tubes are produced by passing a beam of circular cross-section through two successive magnetic lenses.

621.385.029.6 3888
Some Characteristics of a Magnetically Focused Electron Beam—G. R. Brewer. (*J. Appl. Phys.*, vol. 30, pp. 1022–1038; July, 1959.) Describes an experimental study of the detailed behaviour of a solid cylindrical electron beam focused by a uniform magnetic field. A simple model of the beam is used to explain certain of the observed characteristics.

621.385.029.6 3889
Propagation of Electromagnetic Waves in Retarding Systems with a Helix and a Dielectric—B. M. Bulgakov and V. P. Shestopalov. (*Zh. Tekh. Fiz.*, vol. 28, pp. 188–201; January, 1958.) Mathematical analysis for an electron beam in a helix located in a dialectric medium. Possible modifications in the design of this structure are discussed.

621.385.029.6:621.372.413 3890
General Treatment of Klystron Resonant Cavities—K. Fujisawa. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. MTT-6, pp. 344–358; October, 1958. Abstract, PROC. IRE, vol. 47, p. 112; January, 1959.)

621.385.032.213.13 3891
Preconversion of Oxide Cathodes—G. A. Haas and J. T. Jensen, Jr. (*Rev. Sci. Instr.*, vol. 30, pp. 562–565; July, 1959.) Reduction in the contamination of thermionic tube components and improved cathode emission characteristics are obtained if the oxide cathodes are preconverted in a separate envelope and then transferred to the final tube as the alkaline earth hydroxide.

621.385.032.213.13 3892
Dissociation of Solid SrO by Impact of Slow Electrons—G. E. Moore. (*J. Appl. Phys.*, vol. 30, pp. 1086–1100; Ju y, 1959.) Positively and negatively charged dissociation products were identified using a mass spectrometer method.

621.385.032.213.6 3893
High-Current-Density Thermionic Emitters: A Survey—A. H. W. Beck. (*Proc. IEE* (London), Part B, vol. 106, pp. 372–388; July, 1959. Discussion, pp. 389–390.) "The steps leading to the development of modern emitters are described and the characteristics and operation of such emitters are discussed."

621.385.032.269.1 3894
Theory of a Space-Charge-Limited-Crossed-Field Gun—R. H. Bartram and M. C. Pease. (*Sylvania Tech.*, vol. 11, pp. 59–65; April, 1958.) A theoretical model for a single-trajectory electron beam is derived and applied to the design of a "ramp" gun. The advantages of this gun in improving the efficiency and tuning range of the backward-wave magnetron oscillator are discussed.

621.385.1 3895
A Comparative Study of Cylindrical, Elliptical and Prismatic Forms of Electronic Tubes—A. I. Vishnievsky, S. Sampath, and C. S. Upadhyay. (*J. Indian Inst. Sci.*, Section B, vol. 41, pp. 1–6; January, 1959.) An earlier study (3531 of October) is extended to cover the elliptical form. For the same electrostatic capacitance and for approximately the same space-charge-limited current, the prismatic form has the best "design parameter" but the elliptical form is structurally more stable.

621.386.1 3896
Microphonic Effects in Electron Tubes—D. Hoogmoed. (*Electronic Applic.*, vol. 19, pp. 25–44; March, 1959.) The causes, consequences and prevention of microphonic effects are discussed.

MISCELLANEOUS

061.4:621.37/.39 3897
National Radio Show—(*Wireless World*, vol. 65, pp. 371–384; September, 1959.) A stand-by-stand report of the exhibition held in London, August 26–September 5, 1959.

061.4:621.37/.39 3898
The German Radio Show—(*Wireless World*, vol. 65, pp. 403–407; September, 1959.) A survey of the exhibition held in Frankfurt, August, 1959.

621.37/.39(47) 3899
Soviet Equipment Design—J. M. Carroll. (*Electronics*, vol. 32, pp. 37–39; July 24, 1959.) A review of current techniques and practice in industrial and domestic equipment.

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Report from IBM *Yorktown Research Center, New York*

MAGNETIC EXPLORATION ALONG THE CRYSTAL AXIS

How does the orientation of crystallites within a thin metallic film relate to its magnetic properties? This is the question under study by a group of scientists at Zurich, Switzerland—one of the laboratories coordinated from the IBM Yorktown Research Center.

Electron-diffraction permits the investigation of the crystal structure of thin magnetic films prepared by evaporation in vacuum. In particular the orientation of the numerous small crystals in a polycrystalline film can be detected. The uniform distribution of density along the rings in the left-hand picture results from a random distribution of crystal axes, whereas the arcing of the rings at the right indicates a preferred orientation, known as fiber texture. Alignment of the axes of the individual crystallites contributes to the film's magnetic anisotropy—the variation of magnetic energy with different directions of magnetization.

Techniques for producing predictable anisotropy in thin films and for measuring magneto-crystalline relationships are among the goals of the present work. Thorough understanding of all factors influencing the magnetic anisotropy is mandatory for the development of optimal operation of magnetic thin film logic and memory devices. Mastery of anisotropic films may thus offer a promising route to greater capabilities in tomorrow's computers.

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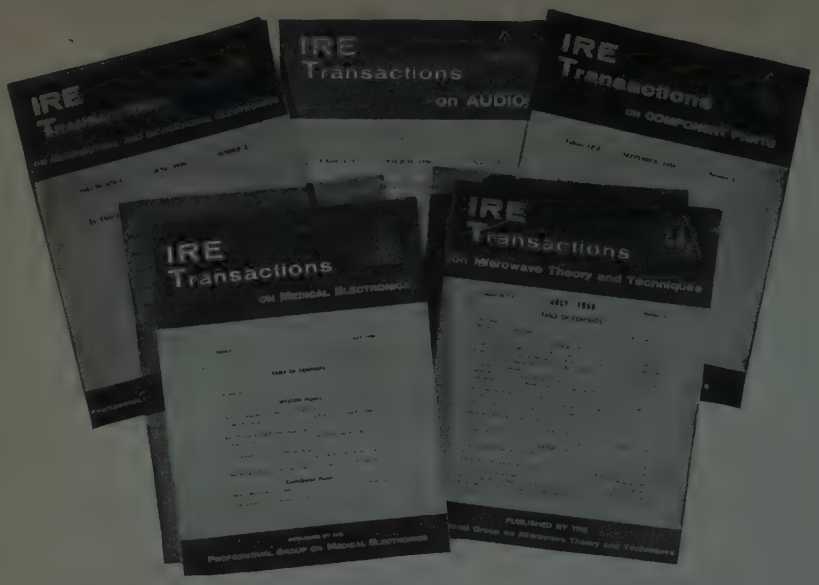

At least one of your interests is now served by one of IRE's 28 Professional Groups

Each group publishes its own specialized papers in its *Transactions*, some annually, and some bi-monthly. The larger groups have organized local Chapters, and they also sponsor technical sessions at IRE Conventions.

Aeronautical and Navigational Electronics (G 11)	Fee $2
Antennas and Propagation (G 3)	Fee $4
Audio (G 1)	Fee $2
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IRE Professional Groups are only open to those who are already members of the IRE. Copies of Professional Group Transactions are available to non-members at three times the cost-price to group members.

The Institute of Radio Engineers
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Professional Group On Communications Systems

The field of communications systems is as old as radio itself. For three decades after Marconi first spanned the Atlantic by radio in 1901 radio researchers devoted practically all their efforts to developing and perfecting new systems for utilizing electromagnetic waves for communication purposes.

Gradually, however, this new found knowledge opened the doors to other applications in industrial, military, scientific, and medical fields. Under the stimulus of wartime research these newer applications multiplied and expanded at a tremendous rate so that at the end of World War II the complexion of the radio engineering field had altered drastically.

What had once been a fairly small, homogeneous group with common technical interests had now become a large body of engineers and scientists working in at least a score of separate and distinct specialized fields. Communications engineers found it increasingly difficult to find the specialized technical information they urgently needed since the sources for such information now had to serve many other fields as well.

On April 8, 1952, the IRE formed the Professional Group on Communications Systems. The response was almost instantaneous as communications engineers all over the U. S., and in other countries as well realized that for the first time an organization had been formed just to serve their particular technical needs.

As membership increased, the Group began publishing its own TRANSACTIONS, which is issued free to all members. This year alone, Group members received 300 pages of valuable technical papers. The Group also has become very active in sponsoring meetings in various parts of the country throughout the year. The value of these activities is attested to by the fact that some 3000 engineers have joined the Group and have found this affiliation indispensable to their professional well being.

W. R. G. Baker

Chairman, Professional Groups Committee

NEW Corning wafer capacitors run from 1 to 10,000 uuf

Uuf for uuf the smallest, most stable capacitors you can get for printed circuits and high reliability components.

Never has so much capacitance been crammed into so little space with so much ruggedness and reliability.

The smallest gives from 1 to 560 uuf while resting in a space only 0.00204 cubic inch in volume.

The largest runs from 4301 to 10,000 uuf and takes up only 0.02106 cubic inch.

You sacrifice nothing for size. The flat shape gives you more options in mounting, e.g., slot or flat mounting in printed circuits.

When you need leads we can provide those too, in the W-5 and W-4 sizes as WL-5 and WL-4.

These capacitors are rugged and reliable. The dielectric and conductor layers are fused at high temperatures and need no encasement. You'd almost have to smash one completely to stop its operation. Meets or exceeds the performance requirements of MIL-C-11272A.

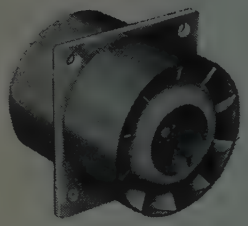
For complete specs write for a new 4-page bulletin to Corning Glass Works, Dept. 542, Bradford, Pa.

Capacitor	Capacitance (uuf)	Volume (approx.)
W-5	1 to 560	0.00204 in.^{3}
W-4	561 to 1000	0.00327
W-3	1001 to 2700	0.00702
W-2	2701 to 4300	0.01951
W-1	4301 to 10,000	0.02106

W-5, W-4 also available with leads as WL-5, WL-4

CORNING ELECTRONIC COMPONENTS

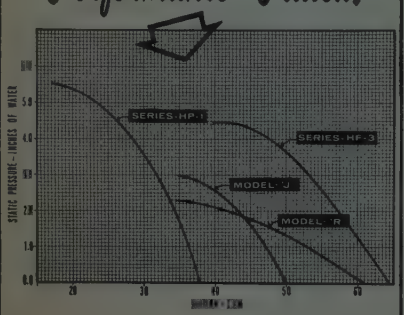
PERFORMANCE BEYOND THE STATE OF THE ART!



With Dean & Bensons

POW AIR

Series HP & HF
Standard 2" Blower
Performance Rated!



- **Greater operating efficiency resulting in increased performance.**
- **Up to 200% greater performance for new design approaches.**
- **Slip out AC or DC Motor allows for easy and inexpensive maintenance without replacing entire unit.**
- **400 Cycle or 28 V. DC units available without design change.**

Flange location anywhere at no additional cost.

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Division of Benson Manufacturing Co.
Kansas City 1, Mo.

NEWS New Products

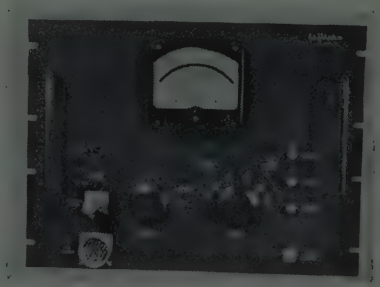
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 108A)

DC-AC Transistorized Inverter

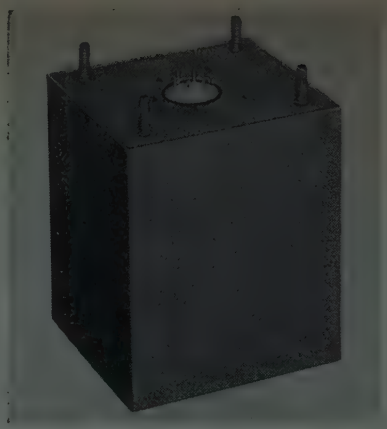
A new 2 kw dc-ac inverter has been added to **Electrodynamic Instrument Corporation's,** 2508 Tangley Rd., Houston 5, Texas, PI Series of transistorized power supplies. The unit will supply a 2 kva output or two 1 kva outputs of 120 volts, 60 or 400 cps, single phase, from an 11 to 14 vdc or 22 to 32 vdc source. Frequency stability of ±.01% and exceptional reliability make these inverters suitable replacements for rotary-type inverters in microwave, telemetry and automatic control installations. Efficiency at full load is about 85%. Solid-state circuit design throughout eliminates the need for standby power or warm-up time. The standard rack panel unit measures 24½×19×12".

Frequency Calibrator



Rapid and accurate calibration of FM/FM telemetering systems is provided with the Model 520 series Frequency Calibrators manufactured by **Fenske, Fedrick & Miller, Inc.,** 12820 Panama St., Los Angeles 66, Calif. Features are accuracy, ease of operation, external metering provisions and elimination of the necessity for highly trained personnel. Calibration time is reduced to approximately 30 seconds per channel. Provisions are also made for crystal outputs for discriminator alignments.

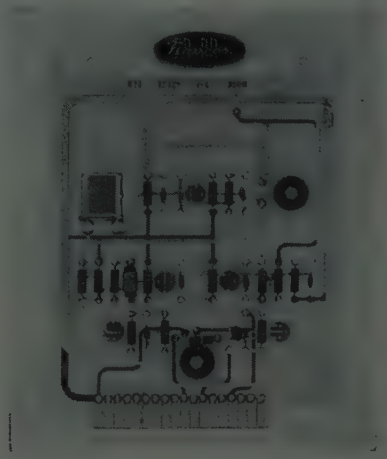
Phase Splitting Transformer



A practical means for operating 3 phase devices where only single phase is available is provided by phase splitting transformers manufactured by **United Transformer Corp.,** 150 Varick St., New York 13, N. Y. The P-4674 unit, illustrated, provides 115 volts, 400 cps 3 phase to a 90 va gyro power supply. Input is 115 volts, 400 cps single phase. This unit is 2¾×3×3½" and weighs 3¼ pounds; meets MIL-T-27A requirement to Grade 4, Class S, Life X.

Pulse Generator

The all transistor Model 300X Pulse Generator, developed by **Navigation Computer Corp.,** 1621 Snyder Ave., Philadelphia 45, Pa., provides accurately timed clock pulses at crystal controlled frequencies.



A standardized 2.5 volt pulse (Vk) of both polarities is generated by a crystal controlled oscillator. The output stage is transformer-coupled and has a constant voltage characteristic which maintains an undeteriorated pulse when loaded between 0 and 100 ma output current.

The Model 300X is fabricated on a 5"×6" glass-epoxy printed circuit card.

(Continued on page 118A)

Use Your IRE DIRECTORY! It's Valuable!

Announcing . . .

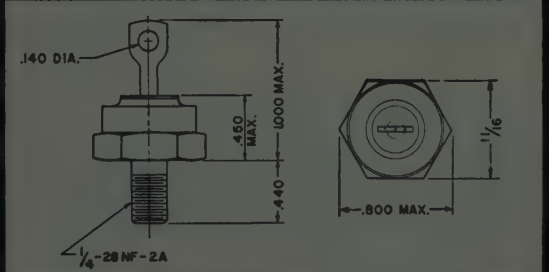
SILICON RECTIFIERS

from DELCO RADIO

High Quality
High Performance
Extreme Reliability

From the leading manufacturer of power transistors, new Silicon Power Rectifiers to meet your most exacting requirements. Even under conditions of extreme temperatures, humidity and mechanical shock, these diffused junction rectifiers continue to function at maximum capacity! Thoroughly dependable, completely reliable—new Delco Rectifiers are an important addition to Delco Radio's high quality semiconductor line.

Conservatively rated at 40 and 22 amperes for continuous duty up to case temperatures of 150°C.



TYPE	AVG. DC CURRENT	PIV	THERMAL MAX. TEMP.	MAX. FORWARD DROP	MAX. REVERSE CURRENT
1N1191A	22A	50V	150°C	1.2V at 60 amps.	5.0 MA
1N1192A	22A	100V	150°C	1.2V at 60 amps.	5.0 MA
1N1193A	22A	150V	150°C	1.2V at 60 amps.	5.0 MA
1N1194A	22A	200V	150°C	1.2V at 60 amps.	5.0 MA
1N1183A	40A	50V	150°C	1.1V at 100 amps.	5.0 MA
1N1184A	40A	100V	150°C	1.1V at 100 amps.	5.0 MA
1N1185A	40A	150V	150°C	1.1V at 100 amps.	5.0 MA
1N1186A	40A	200V	150°C	1.1V at 100 amps.	5.0 MA at 150° C case temperature and rated PIV

For full information and applications assistance, contact your Delco Radio representative.

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Chicago, Illinois
5750 West 51st Street
Tel: Portsmouth 7-3500

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

DELCO RADIO

Division of General Motors • Kokomo, Indiana

IS *YOUR* COMPANY ON THE *OFFENSE* FOR *DEFENSE?*

SIGNAL is your introduction to the men who control the growing $4 billion dollar government radio-electronics spending

Never before have our armed forces so badly needed the thinking and products of the electronics industry. Advertising in SIGNAL, the official journal of the *Armed Forces Communications and Electronics Association*, puts you in touch with almost 10,000 of the most successful men in the field—every one a prospect for your defense products!

Share in the defense and the profits! Company membership in the AFCEA, with SIGNAL as your spokesman, puts you in touch with government decision-makers!

SIGNAL serves liaison duty between the armed forces and industry. It informs manufacturers about the latest government projects and military needs, while it lets armed forces buyers know what *you* have to offer to contribute to our armed might. SIGNAL coordinates needs with available products and makes developments possible.

But SIGNAL is more than just a magazine. It's *part of an over-all plan!*

A concerted *offensive* to let the government, which has great faith in industry and the private individual producer, know exactly what's available to launch its far-sighted plans. Part of this offensive is the giant AFCEA National Convention and Exhibit (held this year in Washington, D.C., June 3-5). Here, you can *show* what you have to contribute directly to the important buyers. Your sales team meets fellow manufacturers and military purchasers and keeps "on top" of current government needs and market news.

Besides *advertising* in SIGNAL which affords year-round exposure by focusing your firm and products directly on the proper market . . . besides *participation* in the huge AFCEA National Convention and Exhibit . . . the over-all plan of company membership in the AFCEA *gives your firm a highly influential organization's experience and prestige to draw upon.*

As a member, you join some 170 group members who feel the chances of winning million dollar contracts are worth the relatively low investment of time and money. On a local basis, you organize your team (9 of your top men with you as manager and team captain), attend monthly chapter meetings and dinners, meet defense buyers, procurement agents and sub-contractors. Like the other 48 local chapters of the AFCEA, your team gets to know the "right" people.

In effect, company membership in the AFCEA is a "three-barrelled" offensive aimed at putting your company in the "elite" group of government contractors—the group that, for example in 1957, for less than $8,000 (for the full AFCEA plan) made an amazing total of *459.7 million dollars!*

This "three-barrelled" offensive consists of

(1) Concentrated advertising coverage in SIGNAL, the official publication of the AFCEA;

(2) Group membership in the AFCEA, a select organization specializing in all aspects of production and sales in our growing communications and electronics industry; and

(3) Attending AFCEA chapter meetings, dinners and a big annual exposition for publicizing your firm and displaying your products.

If *you're* in the field of communications and electronics . . . and want prestige, contacts and exposure . . . let SIGNAL put your company on the *offense* for *defense!* Call or write for more details—now!

SIGNAL AFA

Official Journal of AFCEA

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EXCLUSIVE!
MOLDED* Contact Combinations on OHMITE® Relays

"Molded Module"* Contact Springs

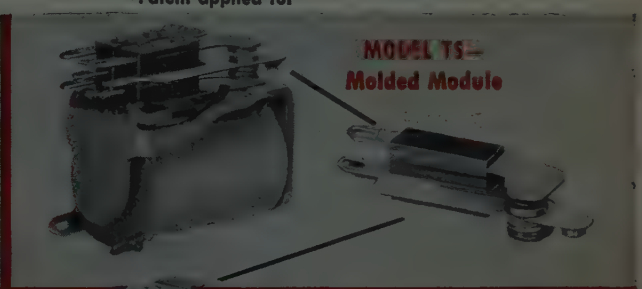
Ohmite Models TT and TS Relays meet the operational requirements of MIL-R-5757C and MIL-R-6106C, respectively, and will be found ideal for aircraft or industrial uses, particularly those involving ambient temperatures as high as 125°C. Both relays are lightweight, yet rugged.

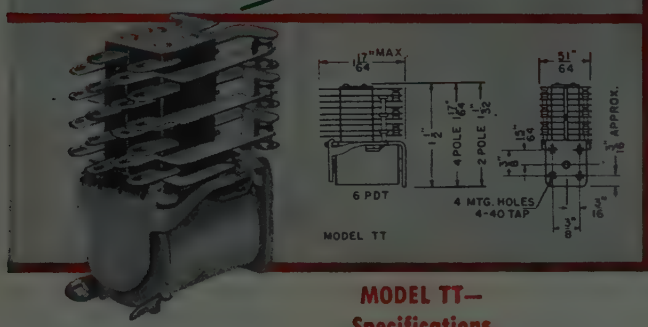
Paramount among the design innovations is their revolutionary "Molded Module" contact spring construction. The "module" is a standard, single-pole, double-throw spring combination molded into a compact assembly. As many as six modules can be incorporated into a relay to provide a maximum six-pole, double-throw combination. With the springs rigidly held in a matrix of tough plastic, alignment of the springs is assured. More accurate alignment of all the subcombinations (modules) on the relay is possible, and adjustment of the individual contact springs is easier and more permanent. Diall Phthallate, the molding material, can withstand temperatures to 400°F.

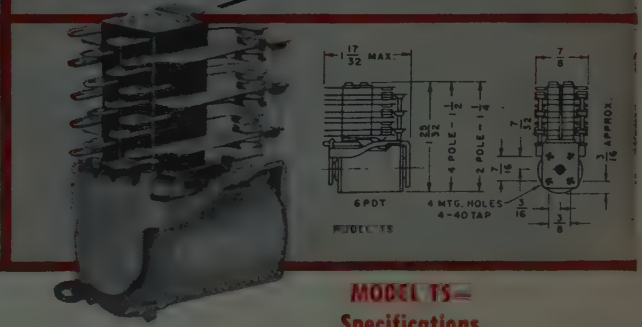
Exceptional sensitivity for small size

A contributing factor to the remarkable sensitivity of Ohmite Models TT and TS Relays is the design of the armature retaining guard to minimize undesirable heel gap. A wide variety of hermetically sealed enclosures is available.

*Patent applied for







MODEL TT— Specifications

COIL WATTAGE: Rated nominally at .150 watt per pole at an ambient temperature of 20°C.

COIL OPERATING VOLTAGE RANGE: To 115 VDC.

CONTACT RATINGS: Up to 5 amperes at 115 volts AC or 32 volts DC noninductive, with standard contact material, palladium. Other materials can be supplied.

CONTACT COMBINATIONS: Standard combinations are DPDT, 4PDT, and 6PDT (maximum). Others can be furnished.

WEIGHT: Approximately 2 ounces for 4PDT relay.

MODEL TS— Specifications

COIL WATTAGE: Rated nominally at .250 watt per pole at an ambient temperature of 20°C.

COIL OPERATING VOLTAGE RANGE: To 115 VDC.

CONTACT RATINGS: Up to 10 amperes at 115 volts AC or 32 volts DC noninductive with standard contact material, silver-cadmium oxide. Other materials can be supplied.

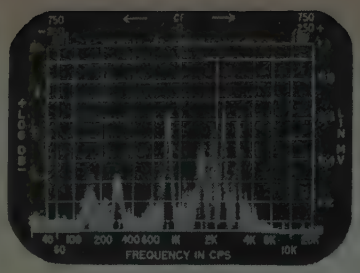
CONTACT COMBINATIONS: Standard combinations are DPDT, 4PDT, and 6PDT (maximum). Others can be furnished.

WEIGHT: Approximately 3 ounces for 4PDT relay.

Be Right with OHMITE® Quality Components

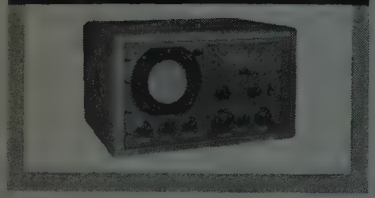
Write for Bulletin 160

OHMITE MANUFACTURING COMPANY
3617 Howard Street, Skokie, Illinois
RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS DIODES
R.F. CHOKES VARIABLE TRANSFORMERS



SEE answers to noise & vibration analysis problems quickly, accurately with..

PANORAMIC'S sonic spectrum LP-1a analyzer



Rugged . . . Reliable . . . Economical

A basic component for waveform study and frequency response curve tracing, the LP-1a is widely used for:

- Vibration and noise measurements
- Harmonic and IM analysis
- Acoustic waveform studies
- Medical electronics

Check these LP-1a features:

- "Quick-look" log sweep; 40 cps to 20,000 cps in 1 second.
- Adjustable linear frequency analysis for 20 cps to 22,500 cps.
- Automatic optimized resolution with variable IF bandwidth options.
- Residual spurious down more than 60 db.
- Optional "M" internal markers at 60 cps, 500 cps and 5 kc (and harmonics).
- Optional "Z" flat face CRT, edge-lit reticule and camera mount bezel.

Write for new Catalog Digest and the Panoramic Analyzer

the pioneer is the leader

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RADIO PRODUCTS, INC.

522 South Fulton Ave., Mount Vernon, N.Y.
Phone: OWen 9-4600
Cables: P-noramic, Mt. Vernon, N. Y. State

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 114A)

1/16" thick, and is adapted for use with an 18 pin printed circuit receptacle.

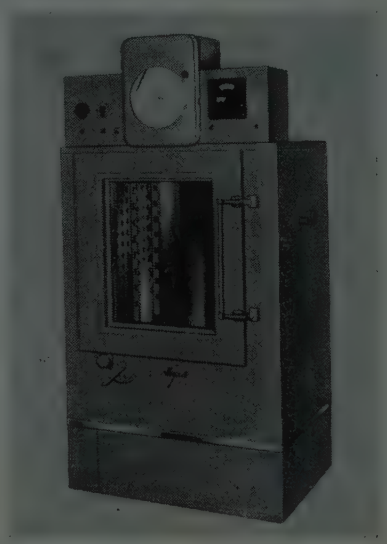
It is accurate to 0.01% of crystal frequency and will operate from 0°F to 135°F.

Available models are the 300X–1, 100 kc; 300X–2, 200 kc; and 300X–3, 300 kc.

Other frequencies are available by special request.

Hot-Cold Test Chamber

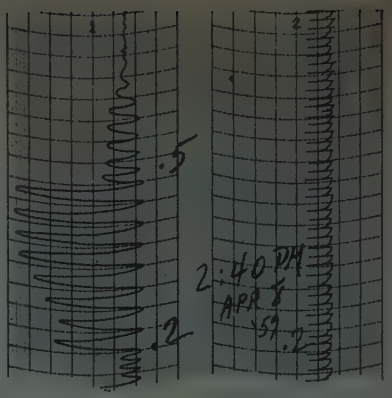
Designed for thermal shock and other controlled temperature testing and conditioning processes involving electronic parts, these chambers manufactured by **Electric Hotpack Co., Inc.**, Dept. 691, Cottman Ave., at Melrose St., Philadelphia 34, Pa., have temperature ranges from −65°F to 540°F.



Maximum temperature uniformity and even CO_2 dispersal is achieved by a built-in air circulation system. Controls include separate thermostats for operation above and below ambient temperatures. Automatic overtemperature controllers are independently circuited to prevent thermal damage to expensive loads in event of main control failure. Temperature chart recorder provides 24 hour record of chamber temperatures.

Cabinet is available in enamelled or heavy gauge stainless steel, and is supplied ready for immediate connection to CO_2 supply. Interior is polished stainless steel. All units are equipped to accommodate through wall connections for test articles. Automatic hot-cold cycles may be supplied if desired.

(Continued on page 122A)



Recorded Events, *only when referred to* Time... *have significance!*

...and with today's accelerating technology, the need for the most accurate time reference available becomes more acute. It *is* available ... and free; the standard time and frequency transmissions of the National Bureau of Standards radio stations WWV and WWVH are accurate to better than 1 part in 50 million and are placed at the disposal of anyone having a receiver capable of tuning to one or more of the transmitting frequencies.

The new Model WWVT receiver, designed especially for remote operations under extreme environmental conditions, is a highly-sensitive crystal-controlled instrument capable of utilizing WWV and WWVH transmission.

Model WWVT

A 6-position dial switches *instantly* to any Standard Frequency — 2.5, 5, 10, 15, 20 or 25 mc. It is small, light-weight and rugged — sealed metal case and potted components, all transistorized and battery operated, and has better than 2 mv sensitivity. Priced at $540.00

Send for bulletin #159A which details many free services available from WWV & WWVH.

SPECIFIC PRODUCTS
Box 425, 21051 Costanso, Woodland Hills, Calif.

–the Standard Line that's Deep-Drawn to Precision Standards*

*The Most Complete Line in the Industry, too!

DESIGNERS!
For precision quality at commercial prices, consult the new HUDSON catalog. Call or write for this cost and time-saving handbook, today!

HUDSON STANDARD CASES AND COVERS offer a quick, economical solution to your military and commercial closure problems. Components of mu metal, nickel-silver, aluminum, brass, copper, steel and stainless steel are available in any required finish.

HUDSON STANDARD TOOLING saves you time and money on all but the most unusual closure applications. Check your requirements with HUDSON engineers, now!

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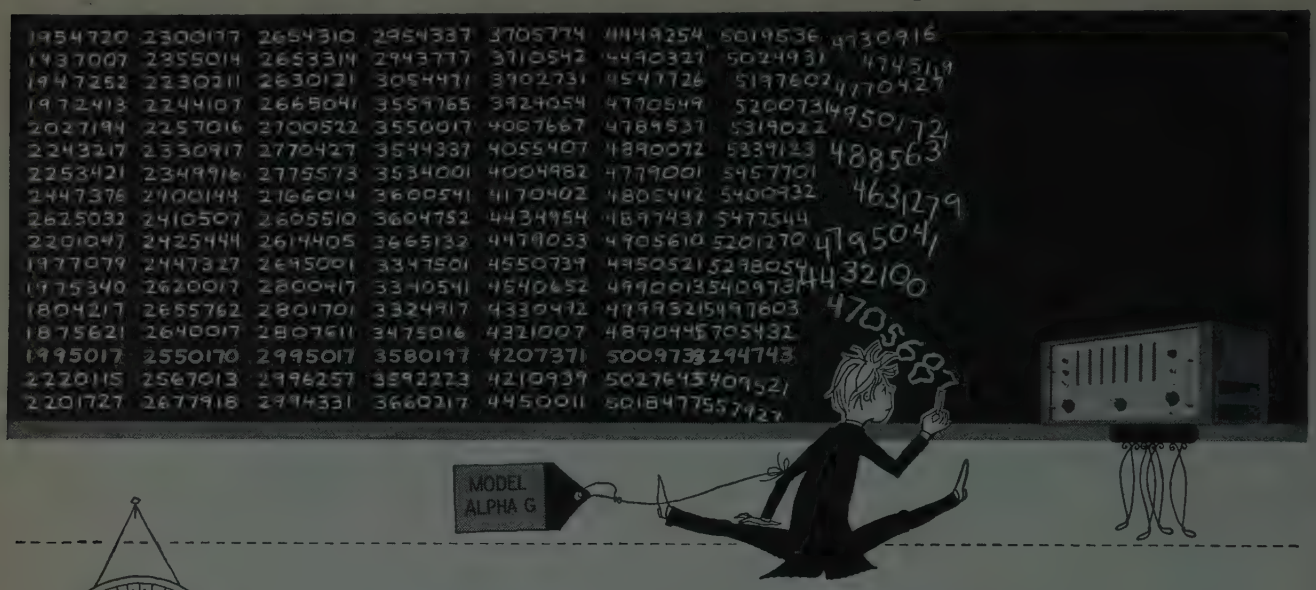
Precision Metal Components for Electronics, Nucleonics, Avionics and General Industrial Applications

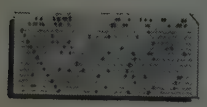
3 MODERN PLANTS TO SERVE YOU

This data converter is no longer available

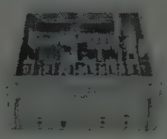


Alfonso Gotlentz, winner of the 1958 Data Conversion Competition, chalked up 16,792 Beckman counter readings in a record time of 7 hrs. 23 min. Unfortunately, Alfonso developed digitized eyeballs, a common occupational disability of mammalian data converters. Undismayed by the untimely end of his conversion career, he speedily procured electroluminescent contact lenses; now performs as a two-digit in-line display.

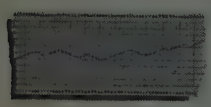
replacing Alfonso, these more clever converters . . .



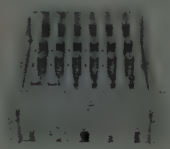
To put Beckman counter readings on punched IBM cards, you can get



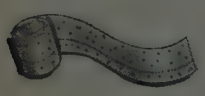
Model 3110 (for serial punch) or Model 3100 (for parallel punch)



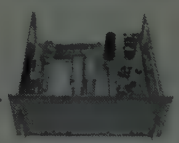
To make a strip chart record of changing counter readings, you may procure



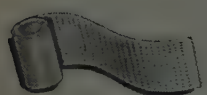
Model 3120, a digital-to-analog converter with resistance ratio output



To make a punched paper tape of counter readings, ask for



Model 3101 (drives a tape punch)



To print counter readings much faster than Alfonso, try

Model 1452, a digital recorder that prints 7, 8 or 10 digits

Beckman

Write for detailed technical bulletins

Berkeley Division
2200 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

MOTOROLA MESA TRANSISTOR

major price reductions make many VHF/UHF applications practical

2N700 FEATURES

f_{osc} (max)	1000 mc
PG (neut.)	14 db @ 200 mc

- **High Temperature Operation.** All units baked-out under high vacuum at 200°C and stabilized at 100°C for 168 hours. Each lot must pass life tests of 1000 hours at 100°C. Units are rated for operation at 100°C.
- **High Efficiency.** A highly efficient oscillator, some points on the 2N700 efficiency-frequency curve are:

Frequency	Efficiency
40 mc	80%
100 mc	62%
200 mc	44%
400 mc	20%

- **Uniformity.** The Motorola Mesas are unquestionably the most uniform transistors available. Instead of the usual "selection process," closely controlled diffusion, etching and evaporative techniques enable Motorola to produce the Mesas to exact specifications. Such uniformity enables the engineer to tighten circuit tolerances, provide improved performance and simplify circuit design. It eliminates concern for variations in such factors as breakdown voltage, current handling capacity, frequency parameters, switching characteristics and saturation resistance.
- **Reliability.** 5,000 hour data on units tested at 100°C show the Motorola Mesa to be the most reliable transistor yet available.
- **Economy.** As the result of major price reductions, the 2N700 is an economical unit for VHF and UHF applications. In addition, fewer units are required on an overall circuit basis because of excellent performance characteristics.
- **Availability.** Engineering quantities are in stock at all 22 Motorola Semiconductor distributors. Production quantities shipped immediately from Phoenix.

Communications Equipment — Because of its small size, the Motorola 2N700 is ideal for low current, compact, highly reliable communications equipment.

IF Strips in Radar Gear — Offering greater gain per stage in its frequency range than any transistor available, the Motorola 2N700 is ideal for radar IF strips in the 60 mc range.

Parametric Amplifier Pump — The 2N700 makes an excellent source of pump power at the frequencies used.

Precision Oscillators — With stability in the order of 10^{-7} to 10^{-8}, the 2N700 is ideal for use in precision oscillators for single sideband and other communication equipment. It also has low phase shift and high loop gain. The 2N700 offers the uniformity and stability important for compact, lightweight precision equipment and instruments.

Oscilloscope Amplifiers — Ideal for instrument probes such as those used to provide preamplification for high speed, high frequency amplifiers.

Fixed IF Strips — Because of its extreme uniformity in all operating characteristics, the 2N700 could be designed into fixed-tuned IF strips, using toroid coils . . . greatly reducing IF strip size and eliminating large tunable elements and alignment problems.

Telemetering — 2N700 operating characteristics are ideal for telemetering applications in the 200 mc band. Its ruggedness (withstands 20,000g's) suggests application in telemetering transmitters fixed to high speed rotating equipment.

FOR COMPLETE SPECIFICATIONS AND DESIGN CONSIDERATIONS
on the 2N700 and the 2N695 (world's fastest switching transistor) contact your nearest Motorola Semiconductor regional office.

REGIONAL OFFICES:

RIDGEFIELD, NEW JERSEY
CHICAGO 39, ILLINOIS
5234 West Diversey Avenue
AVenue 2-4300
HOLLYWOOD 28, CALIFORNIA
HOllywood 2-0821
Outside the U.S.A. and Canada:
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45ex west Augusta Blvd.
Chicago, Illinois

"DEPENDABLE QUALITY - IN QUANTITY"

MOTOROLA SEMICONDUCTORS

MOTOROLA, INC., 5005 E. McDOWELL, PHOENIX, ARIZONA

"A" BATTERY ELIMINATORS

For Demonstrating and Testing Auto Radios

TRANSISTOR OR VIBRATOR OPERATED
6 Volt or 12 Volt!

New Models . . . Designed for testing D.C. Electrical Apparatus on Regular A.C. Lines. Equipped with Full-Wave Dry Disc Type — Rectifier, Assuring Noiseless, Interference-Free Operation and Extreme Long Life and Reliability.

TYPE	INPUT A.C. Volts 60 Cycles	D.C. OUTPUT VOLTS	AMPERES Cont.	AMPERES Int.	SHIP. WT.	USER PRICE
610C-ELIF	110	6	10	20	22	$49.95
		-or-				
		12	6	12		
620C-ELIT	110	6	20	40	33	66.95
		-or-				
		12	10	20		

SEE YOUR JOBBER OR WRITE FACTORY

√NEW MODELS √NEW DESIGNS √NEW LITERATURE
• "A" Battery Eliminators • DC-AC Inverters • Auto Radio Vibrators

ATR AMERICAN TELEVISION & RADIO CO.
Quality Products Since 1931
SAINT PAUL 1, MINNESOTA, U. S. A.

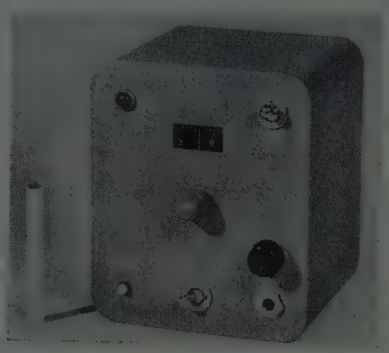
NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 118A)

New Vibration Instrument

An accelerometer sensitivity standardizer called the Dia-A-Gain converts all accelerometer sensitivites to 1 Volt/g, allowing direct reading of acceleration on any VTVM. The Dial-A-Gain includes a cathode follower input and a precision amplifier with a continuously variable gain control dial, calibrated directly in accelerometer sensitivities.



Dialing the sensitivity of your accelerometer automatically adjusts the output to 1 Volt/g allowing direct reading of acceleration on any volt meter.

Dial-A-Gain eliminates external cathode followers normally used, and is available with single or multiple inputs.

For complete specifications, write **Unholtz-Dickie Corp.**, 2994 Whitney Ave., Hamden 17, Conn.

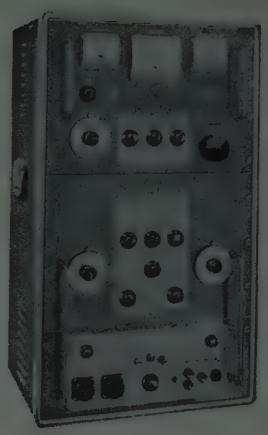
Inductance Bridge

A high-resolution (six-figure) inductance bridge (Type 1632-A) with a basic direct-reading accuracy of 0.1%, designed for the precise measurement of either the series or the parallel components of two-terminal grounded inductors, at audio frequencies, over a wide range of inductance from millimicrohenries to 1111 henries, has been announced by the **General Radio Co.**, West Concord, Mass.

Its high accuracy (two inductors of nearly the same nominal value can be compared to 10 parts in a million) and sensi-

(Continued on page 124A)

IF YOU USE BWOs & TWTs



you need the NEW PRD 813

There is a "spanking" new BWO/TWT power supply that's really a work horse. PRD's latest contribution to the test equipment art, the Type 813 can supply just the right kind of power for driving a host of microwave tubes ranging from voltage-tuned magnetrons to travelling-wave amplifiers.

Featuring the latest advances, the PRD Type 813 has built-in time delays for filament and grid, delay line and collector, and anode voltages... and includes other frustration inhibitors, such as:

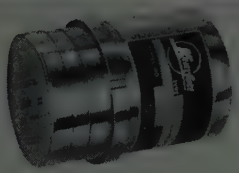
1. Individual adjustments of delay line, collector, anode, grid, and heater elements
2. Provisions for **both** internal and external sweep and amplitude modulation
3. AGC at the grid when used with external detectors
4. Digital read-out for delay line supply.

In addition to these features are the (typical of all PRD equipment) bedrock stability and high sensitivity of the first truly UNIVERSAL BWO/TWT Supply.

The remainder of the features and full specs for the PRD Type 813 can be yours by writing to: PRD—*first in microwaves.*

PRD POLYTECHNIC RESEARCH & DEVELOPMENT CO., INC.
Factory & General Office:
202 Tillary St., Brooklyn 1, N. Y.
ULster 2-6800
Western Sales Office:
2639 So. La Cienega Blvd., Los Angeles 34, Calif.
UPton 0-1940

BASIC BUILDING BLOCKS FROM KEARFOTT



FLOATED RATE INTEGRATING GYROS

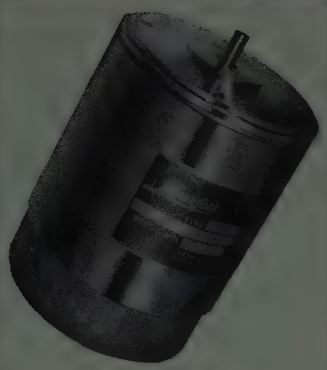
Specifically designed for missile applications, these Kearfott miniature gyros operate efficiently at unlimited altitudes. Their outstanding accuracy and performance make them superior to any comparably-sized units on the market. Hermetically sealed within a thermal jacket, these gyros are ruggedly designed and completely adaptable to production methods. Performance characteristics that are even more precise can be provided within the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
Along Input Axis: 1.0°/ hr maximum untrimmed
Standard Deviation (short term):
Azimuth Position: 0.05°/hr
Vertical Position: 0.03°/hr
Drift Rate Due to Anisoelasticity
Steady Acceleration:
.015°/hr./g^2 maximum
Vibratory-Acceleration:
.008°/hr./g^2 maximum
Damping:
Ratio of input angle to output angle is 0.2
Characteristic Time:
.0035 seconds or less
Weight: 0.7 lbs.
Warm-Up Time:
10 minutes from −60°F
Life: 1000 hours minimum

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



20 SECOND SYNCHRO

This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

TYPICAL CHARACTERISTICS	SIZE 25	
		Control
Type Resolver	Transmitter	Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/80°	8500/80°
Secondary Imped.	260/80°	14000/80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

MINIATURE VERTICAL GYRO

Provides accurate vertical reference in the form of two 400 cps synchro signals proportional to sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed and impervious to sand, dust, sun, rain, salt, spray, humidity or fungus as specified in MIL-E-5272A.

TYPICAL CHARACTERISTICS

Free Drift Rate:
Within 0.5° in one minute time.
Shock:
The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.
Hermetically Sealed:
These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.
Operating Temperature Range:
Gyros operate in ambient temperatures below —20°C to +100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.
Weight:
5.5 lbs. approximately.

Write for complete data.

Time Index Digitalizer

Precise Angle Indicator

Size 8 Integrating Motor Generator

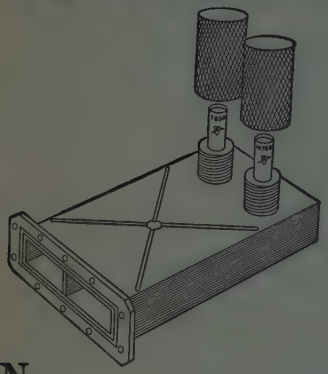
Engineers: Kearfott offers challenging opportunities in advanced component and system development.

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

Microwave Component News from SYLVANIA

Lowest receiver noise figure yet via new Ku Band Diodes



NOW SYLVANIA has new Ku band silicon microwave diodes, types 1N78D and 1N78DR, with a 7.5 db maximum over-all noise figure* for mixer applications.

Extremely low noise figure for Ku band receivers is now possible with a new silicon microwave mixer diode developed by Sylvania, and available in both forward and reverse polarities. When the 1N78D and 1N78DR microwave diodes are used as a matched pair, they virtually eliminate excess noise due to the local oscillator, thus providing a receiver system with a realistic 7.5 db over-all noise figure at Ku band. The use of the matched pair also serves to effectively isolate the antenna and local oscillator terminals.

The new microwave diodes also feature a maximum operating temperature of 150°C as well as a complete hermetic seal for maximum protection under severe environmental conditions.

Contact your Sylvania representative now for complete information on these new low noise Ku band diodes or write the factory directly at the address below.

Write for your free copy of this completely new Sylvania Microwave Diode Characteristics and Replacement Guide.

*with IF amplifier NF equal to 1.5 db

BASIC SPECIFICATIONS OF NEW 1N78D AND 1N78DR DIODES*

Operating Temperature.....150°C max.

NOISE FIGURE (CALC)
N-LC (NIF+NR-1).....NF.....7.5 db max.
where NIF-1.5 db

CONVERSION LOSS.....LC.....5.7 db max.
P-1.0mw, F-16,000 mc
JAN-201 holder

OUTPUT NOISE RATIO.....NR.....1.3 times max.
P/1-0.5
MADC (min), F-9375 mc
JAN-105,202 holder

IF Impedance.....Z_{IF}.....400-565 ohms.

RF Impedance.....VSWR.....1.5 max.

Moisture Resistance.....All units are hermetically sealed and pass MIL-STD-202 Method 106 Moisture Test.

*available also in matched pairs designated 1N78DM and 1N78DMR. Matching criteria are conversion loss within .3 db and IF impedance within 25 ohms of each other.

SYLVANIA GENERAL SYSTEM

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

SYLVANIA ELECTRIC PRODUCTS INC.
Semiconductor Division
100 Sylvan Rd., Woburn, Mass.

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 122A)

tivity (minimum indication—0.001 microhenry) make it suitable for standardization measurements. A novel in-line digital readout features for both inductance and conductance (with automatic positioning of the decimal point) and the absence of a sliding balance also makes possible rapid precision measurements.

The instrument uses the owen circuit, in which inductance is measured in terms of capacitance and resistance; the capacitors and resistors used are accurate to better than 0.05%. Four decades of low-loss polystyrene capacitors and a variable air capacitor (200 $\mu\mu$f–1.111 μf) serve to provide conductance balance.

An outstanding feature is a panel-engraved bridge schematic, complete with balance equations and voltage limits, which eliminates the need to consult an instruction book.

At frequencies up to 1 kc, maximum accuracy is possible; however, the instrument is usable to at least 10 kc, with some reduction in accuracy.

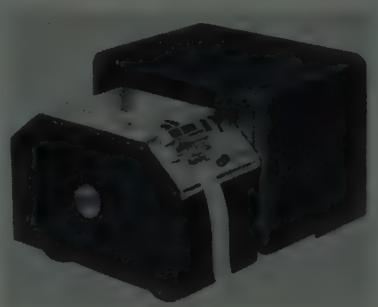
When used in conjunction with standard inductors (G-R Type 1482) in the laboratory, the instrument affords accurate inductance standardization.

Available in an aluminum cabinet and with a crackle finish dress panel, or for rack mounting. Size of the panel is 19″×15¾″; over-all depth is 9⅜″.

Price of the Inductance Bridge (Type 1632-A) is $875.00 net, f.o.b., West Concord, Mass. This instrument may be seen at NEREM, Boston, Nov. 17–19.

Miniaturized Tape Reader

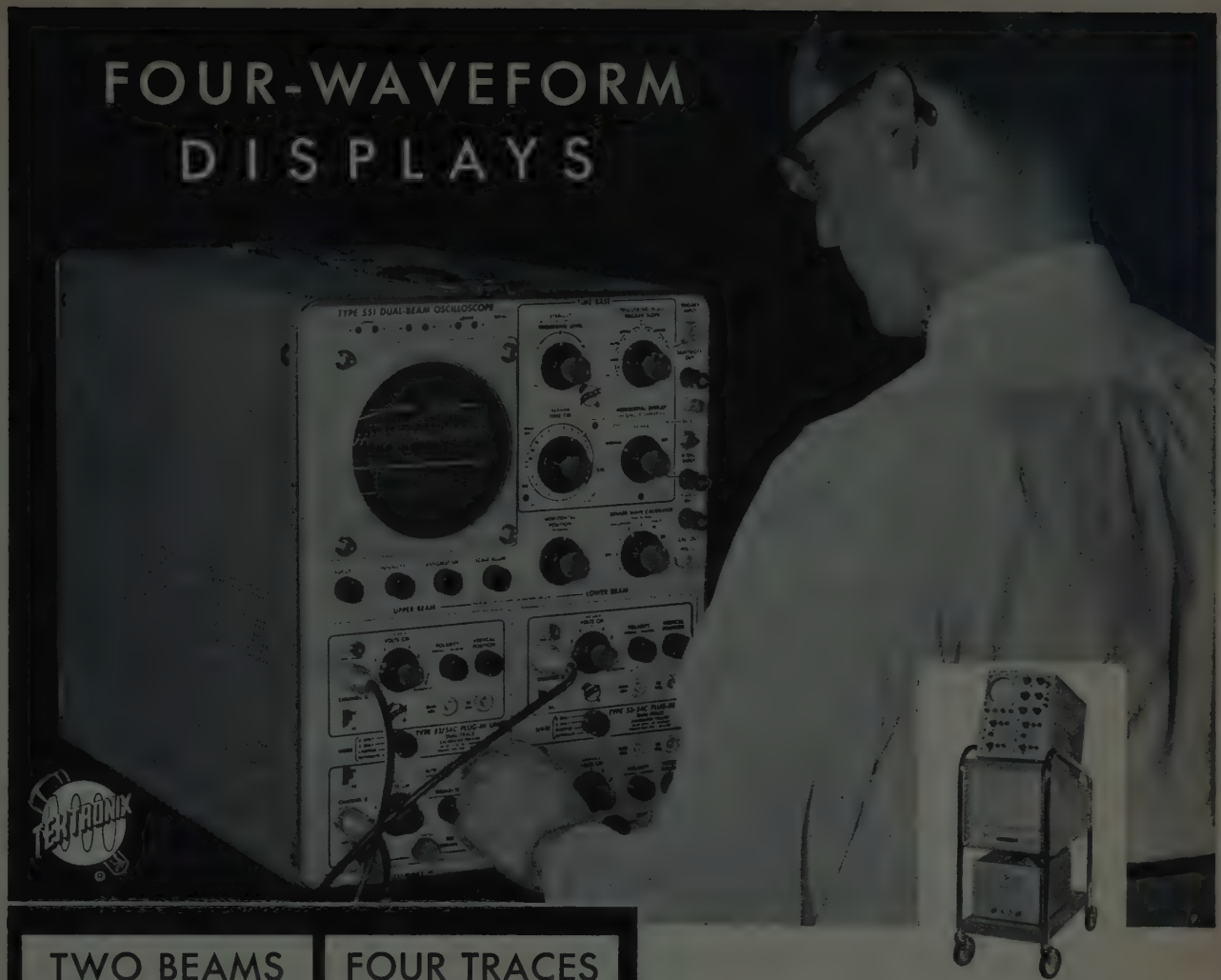
The development of a punched-tape reader set—including transmitter-distributor, motor, base and cover—that is some 40% smaller in size and weight than previous models, has been announced by **Teletype Corp.**, Dept. SP-8, 4100 Fullerton Ave., Chicago 39, Ill.

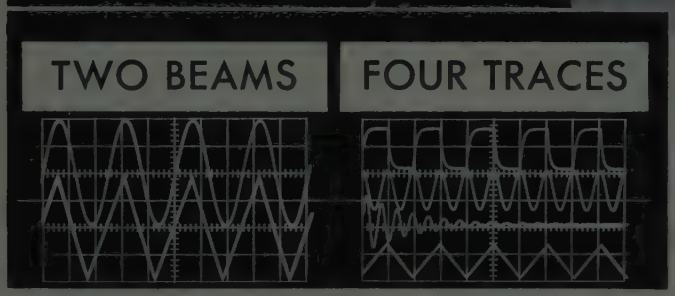


Called the Model 28 Miniaturized LXD set, the reader measures 5¼″ in height, 7½″ in depth and features facilities for sequential (serial) output, hundred-word-per-minute transmission and reduced power requirements. Optimal contacts are available for multi-wire output.

(Continued on page 128A)

FOUR-WAVEFORM DISPLAYS





When the job requires it, you can double up and display four different waveforms at once with this dual-beam oscilloscope. Type 53/54C and/or Type C-A Dual-Trace Plug-In Units in both channels make possible the four-trace display.

Less spectacular but more frequent uses of this versatile fast-rise oscilloscope include waveform comparison measurements on a dual-beam display in the dc-to-25 mc range, and all the usual and unusual applications of a high-performance laboratory oscilloscope.

PRICE
without plug-in units.....**$1800**
Type 500/53A
Scope-Mobile.....**$110**
Type K Fast-Rise
Plug-In Preamplifiers, each.....**$135**
Type C-A Dual-Trace
Plug-In Preamplifiers, each.....**$250**
(f.o.b. factory)

Please call your Tektronix Field Engineer or Representative for complete specifications and, if desired, to arrange for a demonstration at your convenience.

ENGINEERS—interested in furthering the advancement of the oscilloscope? We have openings for men with creative ability in circuit and instrument design, cathode-ray tube design, and semiconductor research. Please write Richard Rapiequet, V.P., Eng.

TYPE 551 *DC-to-25 MC*

Special Features

WIDE-BAND VERTICAL AMPLIFIERS
Main-unit risetimes—12 mμsec.
Passbands and risetimes with Type K (53/54K) units—dc-to-25 mc, 0.014 μsec.

SIGNAL-HANDLING VERSATILITY
All Tektronix A to Z Plug-In Preamplifiers can be used in both channels.

0.2 μsec DELAY NETWORKS

WIDE SWEEP RANGE
0.02 μsec/cm to 12 sec/cm.

SINGLE SWEEPS
Lockout-reset circuitry.

COMPLETE TRIGGERING
Fully-automatic or amplitude-level selection with preset or manual stability control.

10-kv ACCELERATING POTENTIAL
Brighter display for fast sweeps and low repetition rates.

Tektronix, Inc.

P. O. Box 831 • Portland 7, Oregon
Phone CYpress 2-2611 • TWX-PD 311 • Cable: TEKTRONIX

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TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon, Seattle, Wash.; Hytronic Measurements, Denver, Colo., Salt Lake City, Utah.

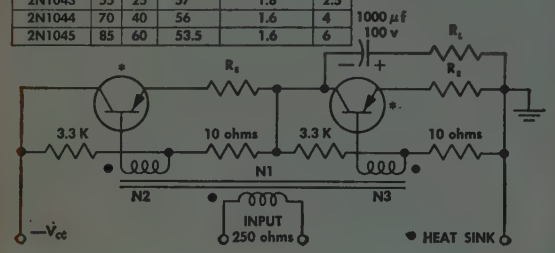
Tektronix is represented in 20 overseas countries by qualified engineering organizations.

Your best combination of I_{CBO}-R_{CS}-V- PLUS HIGH BETA ...TI germanium power transistors!

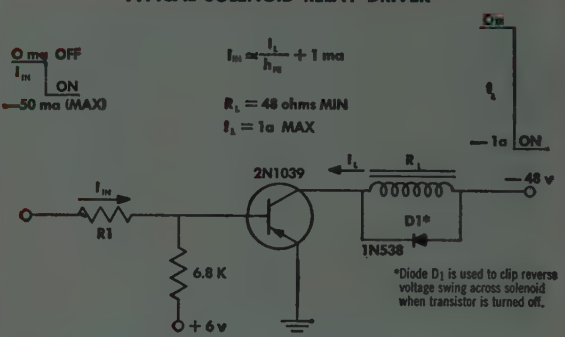
TYPICAL AUDIO AMPLIFIER 10 WATTS OUTPUT

TRANSISTOR	V_{cc} volts	R_L ohms	Efficiency %	Distortion % at P_O=10w	R_s ohms
2N1042	35	10	58	2.7	1
2N1043	55	25	57	1.8	2.5
2N1044	70	40	56	1.6	4
2N1045	85	60	53.5	1.6	6

Transformer: N_1:N_2:N_3 ~ 1:1:1
To Minimize Cross-Over Distortion the Coils Should be Bifilar Wound.



TYPICAL SOLENOID RELAY DRIVER



*Diode D_1 is used to clip reverse voltage swing across solenoid when transistor is turned off.

ACTUAL SIZE

20-w power transistors:

switching circuits • relay drivers • audio and pulse amplifiers

TI 2N1042 series alloy-junction transistors **guarantee** 20 w dissipation at 25°C with voltage ratings of −40, −60, −80, and −100 v. You get guaranteed 20-to-60 beta spread at −3 amps and low 0.16 ohm saturation resistance at the −3 amp maximum collector rating.

ACTUAL SIZE

1.25-w power transistors:

medium speed switching circuits • relay drivers • low-power audio and pulse amplifiers

TI 2N1038 series alloy-junction transistors **guarantee** 1.25 w dissipation in moving free air at 25°C with voltage ratings of −40, −60, −80, and −100 v. **Guaranteed** 20-to-60 beta spread at −1 amp and low 0.2 ohm saturation resistance assure reliable performance.

TI GERMANIUM POWER TRANSISTOR CHARACTERISTICS AT 25°C

Type	Dissipation at 25°C Watts	Max Collector Voltage Volts	Max Collector Current Amps	h_{FE} min	h_{FE} max	Collector Reverse Current I_{CO} max	Typical Saturation Resistance R_{CS} Ohms
2N456	50	−40	−5	10 @ −5a	50	−2ma @ −40v	0.048
2N457	50	−60	−5	10 @ −5a	50	−2ma @ −50v	0.048
2N458	50	−80	−5	10 @ −5a	50	−2ma @ −80v	0.048
2N511	80	−40	−10	10 @ −10a	30	−2ma @ −20v	0.025
2N511A	80	−60	−10	10 @ −10a	30	−2ma @ −30v	0.025
2N511B	80	−80	−10	10 @ −10a	30	−2ma @ −40v	0.025
2N512	80	−40	−15	10 @ −15a	30	−2ma @ −20v	0.025
2N512A	80	−60	−15	10 @ −15a	30	−2ma @ −30v	0.025
2N512B	80	−80	−15	10 @ −15a	30	−2ma @ −40v	0.025
2N513	80	−40	−20	10 @ −20a	30	−2ma @ −20v	0.025
2N513A	80	−60	−20	10 @ −20a	30	−2ma @ −30v	0.025
2N513B	80	−80	−20	10 @ −20a	30	−2ma @ −40v	0.025
2N514	80	−40	−25	10 @ −25a	30	−2ma @ −20v	0.025
2N514A	80	−60	−25	10 @ −25a	30	−2ma @ −30v	0.025
2N514B	80	−80	−25	10 @ −25a	30	−2ma @ −40v	0.025
2N1021	50	−100	−5	10 @ −5a	30	−2ma @ −100v	0.08
2N1022	50	−120	−5	10 @ −5a	30	−2ma @ −120v	0.08
2N1038	1.25	−40	−1	20 @ −1a	60	−125μa @ −20v	0.2
2N1039	1.25	−60	−1	20 @ −1a	60	−125μa @ −30v	0.2
2N1040	1.25	−80	−1	20 @ −1a	60	−125μa @ −40v	0.2
2N1041	1.25	−100	−1	20 @ −1a	60	−125μa @ −50v	0.2
2N1042	20	−40	−3	20 @ −3a	60	−125μa @ −20v	0.16
2N1043	20	−60	−3	20 @ −3a	60	−125μa @ −30v	0.16
2N1044	20	−80	−3	20 @ −3a	60	−125μa @ −40v	0.16
2N1045	20	−100	−3	20 @ −3a	60	−125μa @ −50v	0.16
2N1046	35	−80	−3	20 @ −3a	160	−1ma @ −40v	0.9

germanium and silicon transistors
silicon diodes and rectifiers
tantalum solid tantalum capacitors
precision carbon film resistors
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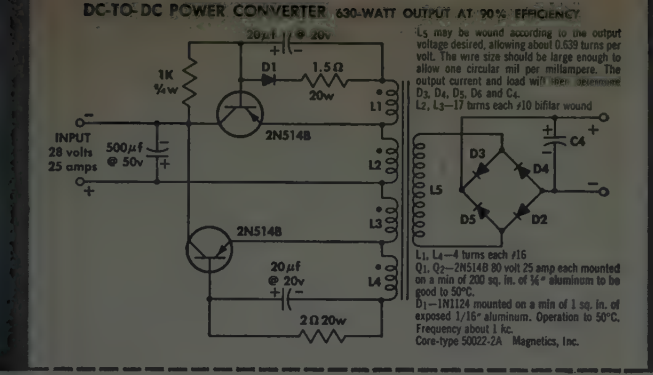
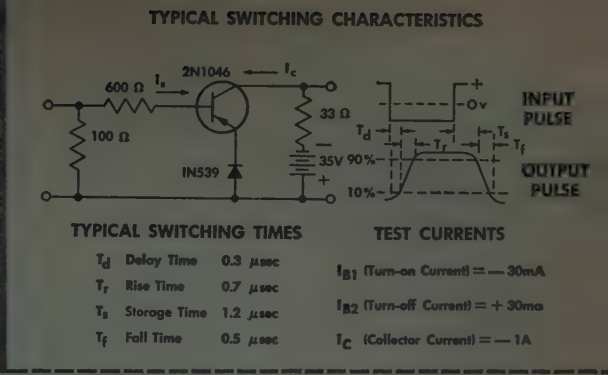
TEXAS


DC-TO-DC POWER CONVERTER 630-WATT OUTPUT AT 90% EFFICIENCY
INPUT 28 volts 25 amps
500μf @ 50v
1K ¼w
D1
1.5Ω 20w
2N514B
2N514B
20μf @ 20v
2Ω 20w
L1
L2
L3
L4
L5
C4
D3
D4
D5
D2
L5 may be wound according to the output voltage desired, allowing about 0.639 turns per volt. The wire size should be large enough to allow one circular mil per milliampere. The output current and load will then determine D3, D4, D5, D6 and C4.
L2, L3—17 turns each #10 bifilar wound
L1, L4—4 turns each #16
Q1, Q2—2N514B 80 volt 25 amp each mounted on a min of 200 sq. in. of ¼" aluminum to be good to 50°C.
D1—1N1124 mounted on a min of 1 sq. in. of exposed 1/16" aluminum. Operation to 50°C. Frequency about 1 kc.
Core-type 50022-2A Magnetics, Inc.



ACTUAL SIZE

10 to 25-amp switchers:

high current switching applications

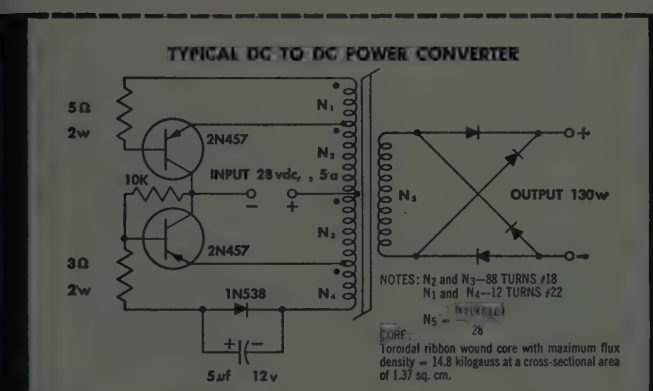
TI 2N511 series alloy-junction transistors **guarantee** collector currents of **—10, —15, —20, and —25 amps** in —40, —60 and —80 v ratings. All units provide low 0.025 ohm saturation resistance and typical switching times at 25°C of 12.5 μsecs (t_{on}) and 8.0 μsecs (t_{off}).

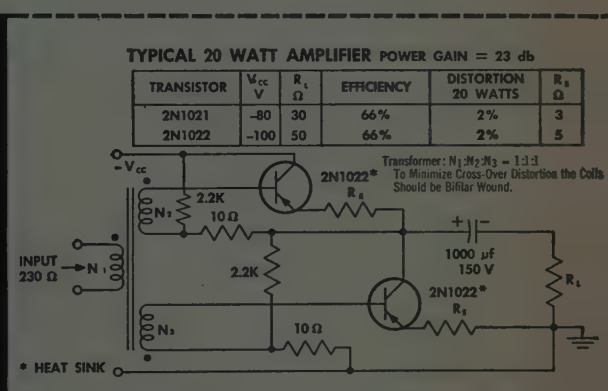
ACTUAL SIZE

high power/high frequency switchers:

computer core drivers • deflection circuit • light weight converter applications

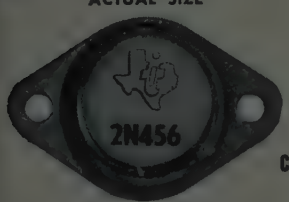
TI 2N1046 alloy diffused transistors combine high power, high frequency and high voltage performance in a single package. **Guaranteed** 35-w dissipation, collector breakdown voltage to —80 v, and low 0.75 ohm saturation resistance with **12 me** typical alpha cutoff insure reliable operating characteristics.




TYPICAL 20 WATT AMPLIFIER POWER GAIN = 23 db
Transformer: N1:N2:N3 = 1:1:1
To Minimize Cross-Over Distortion the Coils Should be Bifilar Wound.
2N1022*
2.2K
10 Ω
1000 μf 150 V
INPUT 230 Ω
* HEAT SINK

TRANSISTOR	V_{cc} V	R_L Ω	EFFICIENCY	DISTORTION 20 WATTS	R_s Ω
2N1021	—80	30	66%	2%	3
2N1022	—100	50	66%	2%	5

ACTUAL SIZE



high beta power amplifiers:

audio amplifiers • current switchers • power converters

TI 2N456 series alloy-junction transistors with **guaranteed** 50-w dissipation, **—40, —60, and —80 BV_{CBO}** ratings and less than 0.048 ohm saturation resistance provide optimum performance characteristics.

ACTUAL SIZE

high voltage power converters

audio • servo • power applications

TI 2N1021 and 2N1022 alloy-junction transistors **guarantee** maximum operating voltages of **—100 v and —120 v** respectively, low 0.08 ohm saturation resistance, and typical betas of 60 at —1 amp, 23 at —5 amps. You get **guaranteed** collector reserve current of —2 ma maximum at full rated voltage.

Check the specifications at left for the unit most suited to your particular requirements.

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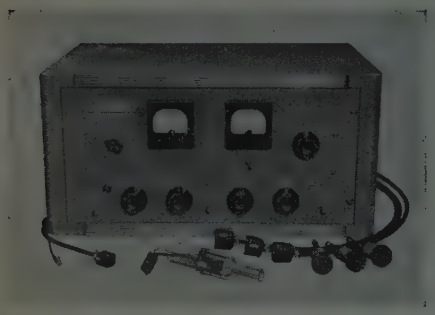

GICT—Cabinet Model

The KINNEY GICT Ionization-Thermocouple Gage covers the range from 3000 microns to below 10^{-7} mm Hg . . . a two meter instrument providing simultaneous Ionization Gage and Thermocouple Gage readings. Available in portable cabinet and panel mounted models. The standard unit is supplied with one position Compensated Thermocouple Gage, and it can be supplied in modified form with 2, 3, 4, 5 or 6 position Gage at extra cost.

Designed with the more critical applications in mind, the KINNEY GICT brings an important advance in high vacuum instrumentation for use wherever an accurate and highly dependable instrument is required.

Get the full story on such features as: Compensated Thermocouple Gage Tubes, Automatic cut-off relay to protect Ion Tubes from burn-out, Outgas circuit for elimination of false pressure readings, and many others.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3631M Washington Street • Boston 30 • Mass.

Please send me Bulletin 3811.1 with full information on the GICT Ionization-Thermocouple Gage by return mail.

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Company_____

Address_____

City_____ Zone_____ State_____

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 124A)

Models may be had to read 5- or 6-level chadless or fully perforated tape.

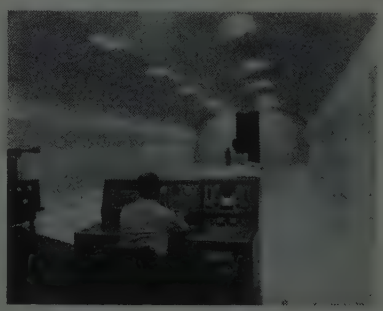
The new set is proposed for a wide range of tape reading applications including on-line data transmission over existing communications facilities and off-line control of tape-operated factory or office machines.

Components of the Model 28 Miniaturized LXD set, such as the transmitter-distributor portion, are available separately (without motor, base or cover) for integration with systems equipment.

A new 4-page applications brochure is available upon request.

Anechoic Chamber

The microwave anechoic chamber shown in the attached photograph embodies advanced design construction. The chamber, designed and constructed by **Emerson & Cuming, Inc.,** Canton, Mass., is about 120′ long, 45′ wide and 25′ high. In contrast with the more conventional darkroom, in which the diffracting edges of transverse baffles lie in planes normal to the long axis of the room, the baffle edges are here parallel to the longitudinal center line. The absorber is Eccosorb FR 340 on the walls, ceiling and floor, with −40 db Eccosorb CV-9 at each end in a vertical cylindrical arrangement. The frequency range is 900 mc through 50 kmc.



Two major electrical advantages accrue from the longitudinal baffle concept First, baffle edge diffraction effects are minimized since the edges are aparallel to the axial field components which are relatively small in most instances. Unless a conventional transversely baffled room is excessively large in cross section, several of the baffle edges are invariably illuminated by parallel fields comparable in amplitude to those illuminating the target area. Recent theoretical and experimental work indicates that, under typical chamber illumination conditions, the very existence of baffle edges parallel to radiation fields imposes a severe limitation upon the "darkness" of a darkroom. The quality of the absorbing material covering these edges is theorectically of little consequence.

(Continued on page 130A)

Just Published—

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The Johns Hopkins University

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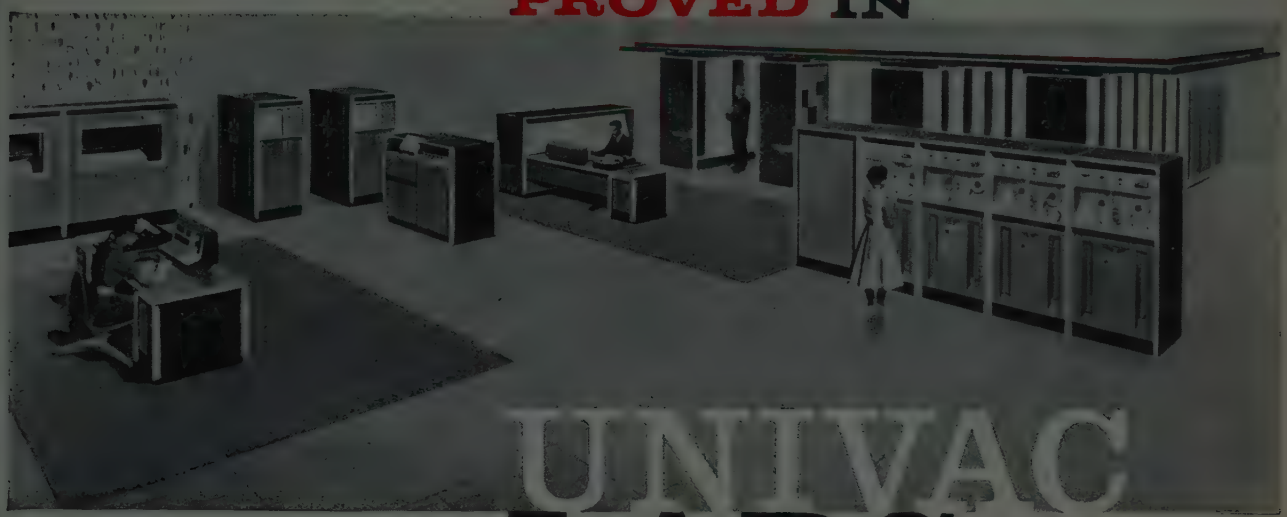

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Selected from Sperry's unique high-current silicon types, these were the only diodes in the industry able to meet the severe performance requirements of the LARC circuitry. Many Sperry computer diodes, such as the 1N690 and 1N691, are finding wide acceptance by the industry in more than a dozen other high speed computer prototypes.

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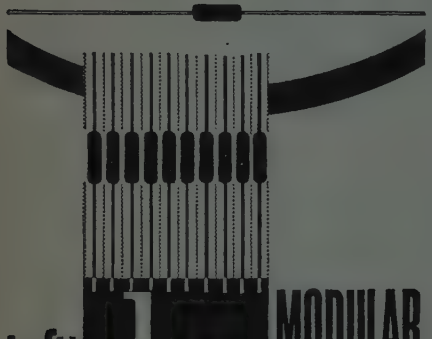

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"NARROW-CAPS" are available in 5 sizes:

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NEWS New Products

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(Continued from page 128A)

The longitudinal-baffle design significantly minimizes these limitations by making the baffle edges parallel to the weak axial field components.

Secondly, the residual and unavoidable reflections from longitudinal baffles impose no limitation on the distance between transmitter and target. A uniformly "quiet" volume, having dimensions subject to design control, surrounds the long axis of the chamber and extends to within a few feet of either end. In a transversely baffled room, an axially short quiet volume exists close to one end, and very elaborate baffling is required to permit a range of transmitter-to-target distances. Additional elaboration of shape and number of transverse baffles is necessary if the room must be used for transmission in either direction, and still further design complications result if the room must be used for both reflectivity and pattern work. In sharp contrast, the much simpler longitudinal-baffle chamber is equally good for transmission in either direction and it is inherently satisfactory for both reflectivity measurement and pattern recording.

The effectiveness of the new design can be readily appreciated by examining the specular reflection paths of rays originating on or near the long axis of the room. In the Canton, Massachusetts, chamber, no energy reflected specularly from walls, ceiling or floor returns to a central 6-foot diameter cylinder except after suffering three reflections from microwave absorbing material. Only a very few "second-bounce" rays traverse an 8-foot cylinder. Testing of the chamber shows the 6-foot diameter cylinder to exhibit −40 db reflection characteristics down to about 1 kmc and −50 db performance from kmc upward. Complete testing will pinpoint reflectivity versus frequency and a plot will be available.

Multi-Circuit Toggle Switch

Electrosnap Corp., 4218 W. Lake St., Chicago 24, Ill., manufacturer of precision switches, has developed a toggle switch, Model A3-77, containing four poles, yet occupying less than one cubic inch of space below the panel.

The switch is designed for aircraft and military use as well as for compact control panels on electrical and electronic equipment. All exposed metal parts are either

(Continued on page 132A)

ripple at full load is only
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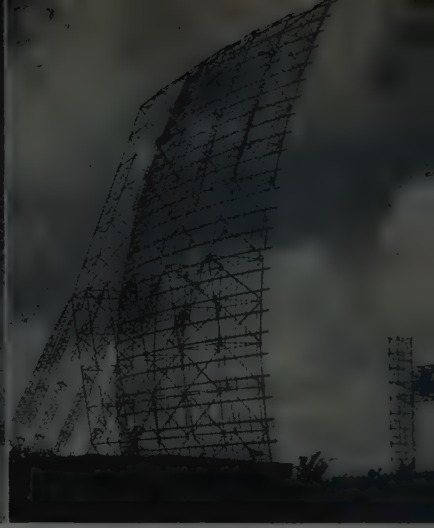

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D **RADIO TELESCOPES** — *An 84-foot radio telescope listens to the heavens whisper. 28- and 60-foot models are also available.*

E **WAVEGUIDE COMPONENTS** — *A dual polarized feed with two waveguide inputs. Other large size components include many types of horns, duplexers, transitions, straight sections and bends.*

F **FIELD SERVICE** — *Kennedy Field Service engineers erect an 84-foot radio telescope. Other services include site selection, constructon, personnel training and servicing.*

G **RESEARCH AND DEVELOPMENT** — *Kennedy's antenna service includes basic R & D in microwave propagation.*

THE solution to antenna problems begins when someone says: "Let's ask Kennedy!"

A few of the many reasons why are shown on this page. These Kennedy antennas are setting new standards for all-weather reliability and versatility wherever they serve throughout the free world.

Kennedy antennas come in many shapes and many sizes. But whatever the type, and whatever the conditions under which it must serve, Kennedy can offer a design that fully measures up to specifications.

Kennedy Field Service engineers are available to install antennas anywhere in the world. It's a part of the complete, integrated service that is still another reason why more and more people in electronics are "asking Kennedy" about antenna problems.

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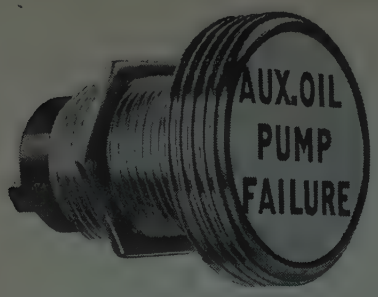

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Bright chrome finish on screw-on type lens-cap. 2-1/8" Overall diameter. Uses S-6 bulb. Depth behind the front of the panel is 2-1/8". 1-3/8" mounting hole diameter. Molded socket with 6-32 terminal screws. U/L Approved.

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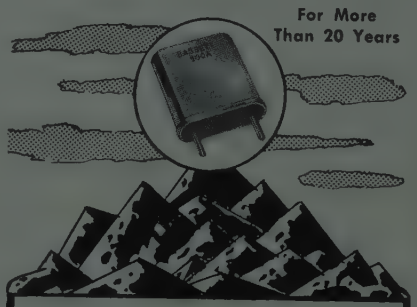

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NEWS New Products

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(Continued from page 130A)

stainless steel or are treated for corrosion resistance. The operating force required to move the bat handle is set above the point where vibration or accidental jarring will actuate the switches. A detent action gives a positive "feel" to the movement of the bat handle from one side to the other.

The bat handle of the switch is maintained in one of three positions with the center position off. Each pole of the switch element is rated at 6 amperes, 125/250 volts ac, 30 volts dc, resistive and 3 amperes, 30 volts dc, inductive, Weight is approximately 1 oz.

For further details, write to Electrosnap.

Sub-Miniature Pulse Transformer

Production of a new sub-miniature pulse transformer featuring clamped ferrite core construction has begun at **Pulse Engineering, Inc.**, 560 Robert Ave., Santa Clara, Calif.

Known as the Micro-Stat®, the new magnetic component uses a high permeability core in the typical CI configuration developed by Pulse Engineering for its ferrite core transformers.

Use of core-gapped construction instead of the conventional toroid and cup core provides improved voltage breakdown and insulation resistance, according to company engineers.

This unique design also features faster reset and less B_r, higher power capabilities, lower losses, and increased total flux swing capability.

The units are constructed on an armite form for precise winding geometry to control leakage inductance and distributed capacity. Each Micro-Stat has a polished gap which represents ½ mil of effective gap.

Micro-Stats are available for immediate delivery in either epoxy construction or in hermetically-sealed metal casings. The epoxy model is 0.41" long with a diameter of 0.30". The metal casing is 0.57" long with a diameter of 0.41".

All applicable military specifications are met by the Micro-Stat. At present, it is available in over 50 designs.

For complete details, please write to the firm.

(Continued on page 134A)

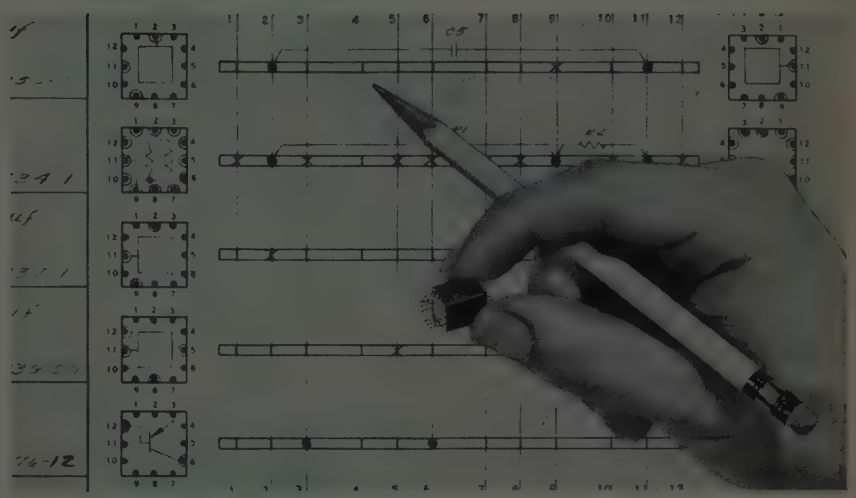
Status Report on RCA Micromodules—
dramatic new devices for high-density parts packaging

How soon will you see your electronic products in Micromodule form?

The excitement over Micromodules is still mounting! We haven't seen such enthusiasm and activity since the early days of transistors. Scores of electronic equipment designers and manufacturers are asking: "How soon can I see my product in Micromodule form?" Our answer: *Right Now!* We'll take your circuit, breadboard, or black box, evaluate it and convert it to module form. In fact, you will find that end-equipment in Micromodule form is probably only *one design cycle away!*

Special Presentation
Now Ready!

RCA Field Engineers are prepared to show you a presentation that will clearly explain the potentialities and the current working realities of Micromodules for application in military computers, digital devices for missiles and satellites, airborne or portable communication equipment, or submarine electronics. Many designers who have seen this presentation were so impressed with the possibilities of extreme miniaturization and increased reliability of Micromodules that they have immediately placed orders to begin micromodularization of their equipment. Call your RCA Field Representative today and he will set up a presentation for you at your convenience.



RCA Micromodules, todays' most exciting, most practical answer to high-density parts packaging, make possible equipment with modular parts densities to 600,000 per cubic foot. Result: important space savings over existing miniature equipment and an amazing increase in the *number of circuit functions* per cubic foot. Increased reliability through redundancy, room for more circuits to improve accuracy, precision, control and sensitivity are other significant advantages offered to designers.

Micromodules, developed through the joint efforts of RCA and other leading component manufacturers, in cooperation with the U.S. Army Signal Corps, are units in which several microelements are combined to perform specific functions such as amplifier, oscillator, or divider. The microelements are tiny ceramic wafers .310 inches square and 1/100th inch thick, on which conducting, semiconducting, and insulating materials are fused to provide the electrical characteristics of basic electronic components such as resistors, capacitors, and transistors. The microelements are interconnected and encapsulated to form Micromodules.

RCA FIELD OFFICES

East:	744 Broad Street, Newark, N. J. HUmboldt 5-3900
Northeast:	64 "A" St., Needham Heights 94, Mass. HIllcrest 4-7200
East Central:	714 New Center Bldg., Detroit 2, Mich. TRinity 5-5600
Central:	Suite 1154, Merchandise Mart Plaza Chicago, Ill., WHitehall 4-2900
West:	6355 E. Washington Blvd. Los Angeles, Calif., RAymond 3-8361
Gov't:	224 N. Wilkinson St., Dayton, Ohio BAldwin 6-2366 1625 "K" St., N.W., Washington, D.C. District 7-1260

ALSO AVAILABLE AT YOUR LOCAL RCA SEMICONDUCTOR DISTRIBUTOR

RADIO CORPORATION OF AMERICA
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HIGH SPEED
Sensitive Polarized
RELAYS

"DIAMOND H"

SERIES P
Relays

For electronic and communications applications

Engineered to provide extremely fast action with high sensitivity, freedom from bounce and excellent stability, "Diamond H" Series P Polarized Relays give consistent performance with low distortion. Under some conditions they will handle over 1,000 pulses per second.

Magnetically latched SPDT, with two independent coils, Series P Relays are available with various coil resistances from 10 to 4,000 ohms each coil. Contact ratings will vary with switching speeds desired, but range from 60 milliamperes to 2 amperes.

Extremely compact, to save space and weight, they fit standard octal sockets. Their impact and vibration resistance is excellent for relays of this type, thanks to extra-rugged construction.

"Diamond H" engineers are prepared to work out a variation to meet your specific requirements. Write or phone us your needs.

THE HART
MANUFACTURING COMPANY
302 Bartholomew Avenue
Hartford, Conn.

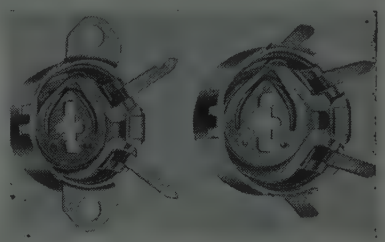
NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 132A)

Preset Wirewound Variable Resistors

A new line of $\frac{3}{4}$" diameter lower cost miniature preset wirewound $\frac{1}{2}$–5000 ohms resistance range variable resistors has been developed by **Chicago Telephone Supply Corp.**, Elkhart, Ind.



Positive contact with the resistance winding at every point of rotation is insured by special alloy spring contactor. Continuous contact between contactor, rotor and cover is provided by 3 embossed dimples on the contactor. Dimensional stability under high humidity conditions is achieved by using fine grade winding strip material with low moisture absorption. This avoids the hazard of winding turns loosening or shorting after humidity exposure. Controls are designed for sensitivity, hum balance, bias adjust and other applications requiring a highly reliable preset wirewound control at lower cost. Rotational torque is 2 to 8 oz./in., stop torque 12 in./lbs. minimum and angle of rotation 240° ±5° without fixed resistor stop. Type 110 is available with straight or snap-in mounting tabs and terminals for printed circuits and Type 112 with flange type cover for eyelet or rivet mounting. Moveable contactor is connected electrically to the cover in both types.

Computing Navigation Indicator

John Oster Manufacturing Co., Avionic Div., 1 Main St., Racine, Wis., has developed a new computing indicator combining the functions of the ID-250/ARN Course Indicator, the ID-307/ARN Azimuth Indicator and the ID-310/ARN Range Indi-

(Continued on page 138A)

PUBLI SERVICE

the 3rd international exhibition of electronic components

IN PARIS
FROM FEBRUARY
19th TO 23rd
1960

The greatest world gathering in the field of electronics.

Recognized Travel Agency :
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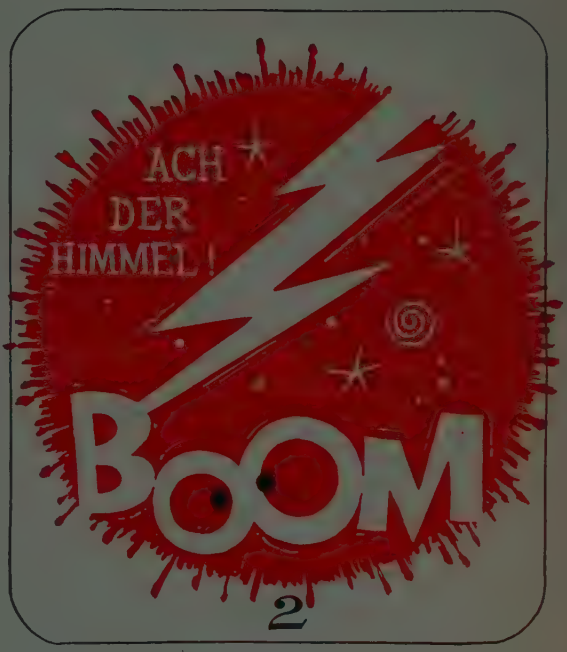
PROFESSOR MIZZLE VON BOMB presents

Great Moments In Electronics

(Never Before Recorded)



BUT
HERR FRANKLIN
VILL GET
DER CREDIT

Yes, Professor . . . "dot iss electricity" . . . discovered through bold research. And such research at SIE has produced the Model R-3 Transistorized Voltmeter, which combines more desirable features than any other instrument in its class.

AC: 1 mv to 1000 v full scale in 14 ranges

DC: 1 v to 1000 v full scale + or — in 7 ranges

Electrometer: 0 to 1 vdc + or —

Ask your SIE representative to demonstrate the R-3 and the entire line of SIE Advanced Design Instruments. "Do itt zoon!"

Write today for prices and specifications.

SIE — ONE OF THE DRESSER INDUSTRIES

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

A DIVISION OF DRESSER INDUSTRIES, INC.

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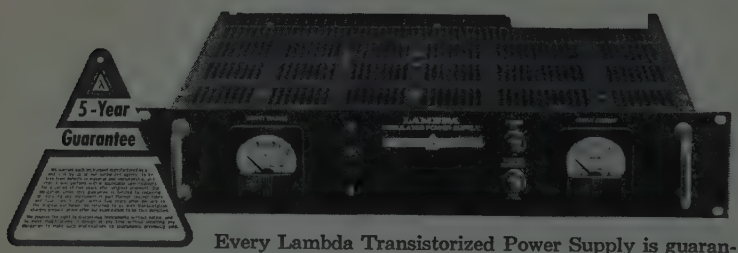
CABLE: SIECO HOUSTON TWX: HO-1185

31 reasons why Transistorized GUARANTEED

LAMBDA LT TRANSISTORIZED POWER SUPPLIES

IMMEDIATE DELIVERY FROM STOCK



Every Lambda Transistorized Power Supply is guaranteed to perform within applicable specifications and is further warranted to be free from defects in material and workmanship for a period of five full years. This plus the excellent experience of present users is your assurance of getting the finest in power supply service when you specify Lambda.

Voltage Bands .....0-8, 8-16, 16-24, 24-32 VDC

Line Regulation .....Better than 0.15 per cent or 20 millivolts (whichever is greater). For input variations from 105-125 VAC.

Load Regulation .....Better than 0.15 per cent or 20 millivolts (whichever is greater). For load variations from 0 to full load.

AC Input .....105-125 VAC, 50-400 CPS

Electrical Overload Protection .....Magnetic circuit breaker, front panel mounted. Unit cannot be injured by short circuit or overload.

Thermal Overload Protection .....Thermostat, manual reset, rear of chassis. Thermal overload indicator light, front panel.

Size .....3½" H x 19" W x 14⅜" D.

CONVECTION COOLED

No internal blowers – No moving parts

0-32 VDC • 0-1 AMP • 0-2 AMP

- **Ambient 50° C at full rating.**
- **High efficiency radiator heat sinks.**
- Silicon rectifier.
- 50-400 cycles input.
- Special, high-purity foil, long-life electrolytics.

- **Compact. Only 3½" panel height.**
- **Short-circuit proof.**
- Protected by magnetic circuit breakers.
- Hermetically-sealed transformer. Designed to MIL-T27A.

- **All transistor. No tubes.**
- **Fast transient response.**
- Excess ambient thermal protection.
- Excellent regulation. Low output impedance. Low ripple.
- Remote sensing and DC vernier.

- Model LT 1095 $285
- Model LT 1095M (metered) $315
- Model LT 2095 $365
- Model LT 2095M (metered) $395

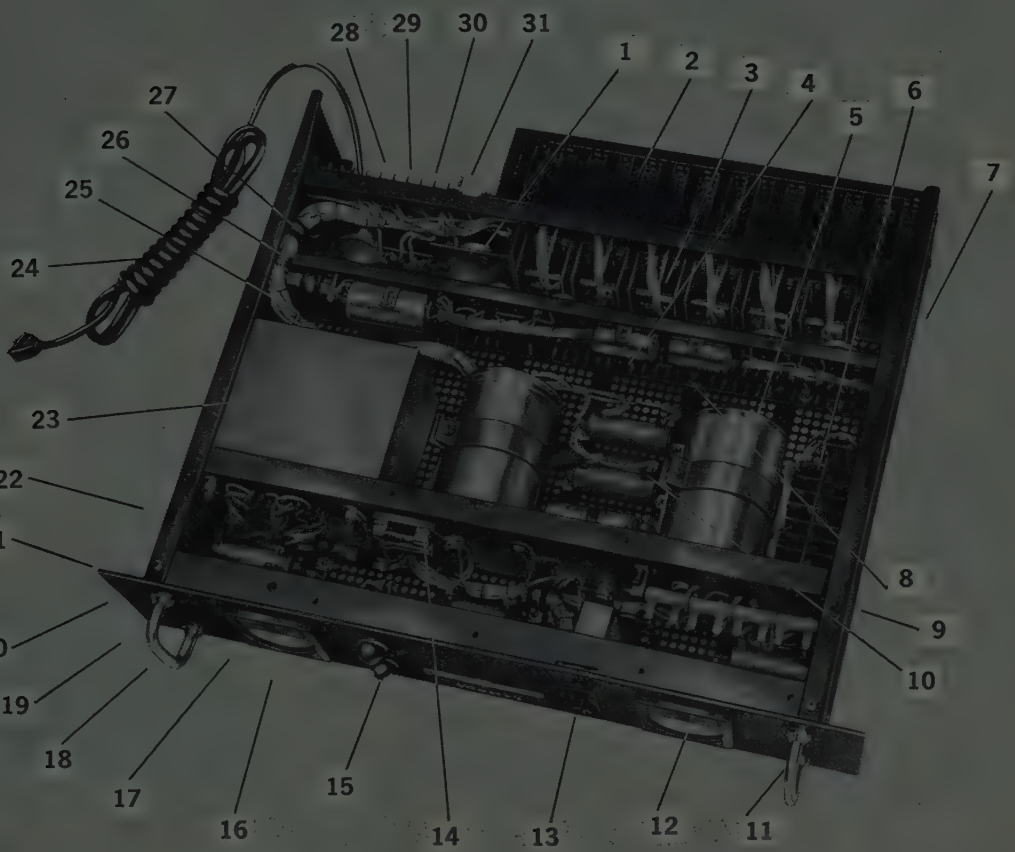
SEND FOR COMPLETE DATA

Write for information and specifications on Lambda's full line of transistor-regulated and tube-regulated power supplies.

LAMBDA ELECTRONICS CORP.

11-11 131 STREET • COLLEGE POINT 56, N. Y. • INDEPENDENCE 1-8500

Lambda Power Supplies are FOR 5 YEARS!



1 Thermal overload breaker for excess ambient temperature protection

2 High efficiency, convection heat sinks

3 Industrial type power transistors inherently protected against overload

4 Highly stable Zener voltage reference diode

5 Special, high-purity foil, hermetically sealed, long-life electrolytic capacitors

6 Silicon rectifier

7 Excellent regulation, low output, impedance, low ripple

8 Stable, low-noise wire-wound reference networks and multipliers

9 Unit welded chassis and frame

10 Every connection and solder joint individually inspected and checked

11 Sturdy gripping handles

12 Meters on "M" models

13 Magnetic circuit breaker

14 Fuses, internal failure protection

15 Thermal overload indicator light

16 Fast transient response

17 Every specification lab-checked before shipment

18 Rated for full load over entire voltage range

19 Advanced packaging for optimum thermal and mechanical design

20 Rated for 24-hour continuous duty

21 Compact — only 3½" panel height

22 Rated for operation from 50-400 cycle source

23 Hermetically-sealed transformer — designed to Mil-T 27A

24 Heavy-duty extra-length industrial cord

25 Harness wiring

26 Nylon jacketed vinyl wire

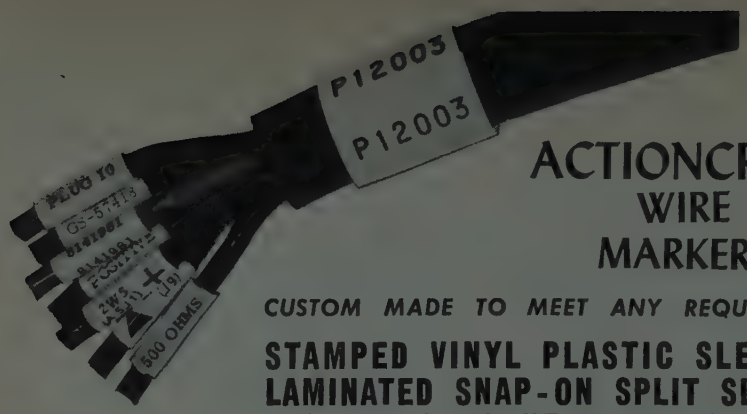
27 Sturdy cable clamp anchors

28 Remote DC vernier adjustment terminals

29 Remote sensing terminals

30 All controls clearly identified and marked

31 Heavy-duty barrier-type terminal block located for convenient rack cabling



ACTIONCRAFT WIRE MARKERS

CUSTOM MADE TO MEET ANY REQUIREMENT

STAMPED VINYL PLASTIC SLEEVING
LAMINATED SNAP-ON SPLIT SLEEVES
STAMPED SILICONE RUBBER SLEEVING

Permatag wire markers are furnished in bulk or carded in sequence according to blue prints or wiring diagrams.

AUTHORIZED DISTRIBUTOR FOR

Phone or write for samples and quotations.

RESINITE SOFT-WOUND INSULATION SLEEVING IS AVAILABLE FROM STOCK

"Soft-Wound" is a new concept in spooling and coiling insulation sleeving. It is carried in stock to meet the following mil specs: MIL-I-631C, MIL-I-7444A(2), MIL-I-3190.

"Soft-Wound" reduces costs—saves time—eliminates waste. An exclusive feature found only in Resinite insulation. Request our Borden Company bulletin RS 113 for complete details showing how "Soft-Wound" saves time and money.

PHONE: PORT WASHINGTON 7-4500

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2 YENNICOCK AVENUE ● PORT WASHINGTON, N. Y.

RIXON SAYS THANKS!

We thank our customers for such fine compliments as:

"A fine packaging job," says one customer.
"A simple but effective data transmission system," says another.

They were talking about the SEBIT-25, a high speed Data Modem that can reliably transmit and simultaneously receive 2500 bits a second over a normal 3-kc voice line.*

Management by Professional Engineers is the impelling force that enables Rixon to challenge the industry in the field of communication-oriented equipment.

RIXON is dedicated to:

- **Developing and building *simplified* but efficient high speed data-stream-handling apparatus.**
- **Solving your difficult electronic problems in the fields of:**

BASIC DESIGNING	To meet your special requirements
PACKAGING and REFINEMENT	Of your own breadboard designs
PRODUCING or SUBCONTRACTING	Electronic assemblies ranging from miniature modules to high power transmitters.
EXPEDITING	Your "Quick Reaction" Contracts.

* For customer-sponsored performance data on SEBIT-25—REQUEST M-24

RIXON ELECTRONICS, INC. ● 2414 Reedie Dr. ● Silver Spring, Md. ● LO 5-4578

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 134A)

cator into a single extremely compact unit. Type 9814-02 eliminates 2 indicators from the instrument panel and weighs 50% less and has 60% less volume than the 3 units it replaces. Overall length is $9\frac{1}{4}$", diameter $3\frac{1}{8}$" and weight $4\frac{1}{2}$ lbs. Maximum. The unit contains 14 major components consisting of 3 ac servo motors, 4 resolvers, 1 control transformer, 1 torque receiver, 4 potentiometers and 1 servo amplifier. The entire mechanical portion is hermetically sealed. One of the unit's computers determines aircraft distance from a Tacan beacon and another computer, aircraft bearing with respect to beacon. For the pilot's convenience, the single indicator face presents compass information on a rotating compass card, distance information on a 3 digit counter and relative Tacan bearing information on a double-bar pointer. An auxiliary single bar pointer is provided for use with other navigational systems. Designed for use with Tacan Receiver-Transmitter Units such as ARN21 in connection with an MA-1 Compass System.

DC Signal Sources

The first commercially available dc signal sources for digital programming have been introduced by **Consolidated Avionics Corp.**, 800 Shames Dr., Westbury, L. I., N. Y., a subsidiary of Consolidated Diesel Electric Corporation, company spokesmen report.

Typical uses, according to the manufacturer, include data systems, automatic checkout equipment and precision testing applications, both in the laboratory and on the production line.

Output voltages are determined by the digital code, in the form of external contact closures, applied to the programming input terminals. Standard units are for three binary-coded decimal digits; other codes are available. The three digits may be fed serially or simultaneously. External contacts must remain closed three milliseconds in order to register. Units also incorporate a clock closure circuit for timed programs.

Output voltage stability is 0.05 per cent under any combination of the following

(Continued on page 140A)

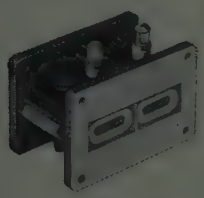
New parametric amplifiers for 4 to 14 db improvement in receivers operating within the 100-1500 mc range.

New ruggedized magnetrons for increased reliability of air-borne systems.

New ferrite duplexers, isolators and circulators for advanced systems.

New computer diodes with recovery times lower than 4 mμ secs.

New Varactor diodes that reduce receiver noise to as low as 1 db.



New duplexer tubes that guarantee crystal protection up to 1000 hours and at elevated temperatures.

New solid-state limiters that protect receivers without external bias.

PROGRESS AT MICROWAVE

has a unique 12-month pattern . . .

This pattern of progress at Microwave Associates during the past 12 months reveals a unique combination of solid state and microwave competence. It shows a new-development pace unmatched by any other single source in the microwave field. It promises that your own microwave system planning can benefit from close cooperation with our skilled team of physicists, metallurgists and engineers. Let's move ahead *faster . . . together!*

For data and prices on any of these new products . . . or for engineering cooperation in developing systems components for your specialized needs, write or call:

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASS. BRowning 2-3000

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE CORPORATION, ROME, N. Y.
PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

BEHIND THE NEUTRON CURTAIN. It may be that the Russians are planning to create an immense neutron cloud cover by setting off a series of high-altitude (300 miles and up) atom and hydrogen bomb blasts. Such a cloud cover would act as a sort of shield against atomic warheads, heating atomic missiles that travel at speeds of 15,000 mph and causing the uranium 235 or plutonium to melt. The atomic engines of planes would also be destroyed in this way. The destructive clouds would probably move in well-defined paths, the Russians theorize, and could also be used to destroy life aboard manned satellites.

WANTED: *By the Air Force:* a non-radiating range-measuring device capable of ranging 20,000 to 30,000 feet ahead of aircraft flying at 500-1000 feet absolute altitude. *By the Navy:* some sort of electronic device that can detect atomic submarines at long distance. Problems that must be overcome: subs are quiet, don't surface, are fast. Some consider atomic subs to be the greatest menace of World War III. The jackpot could run to billions of dollars for the electronics company that solves the detection problem. *By the Air Force:* a means of identifying overstressed materials before failure occurs, to solve the problem of detecting impending failure in rotor blades and components.

FRIENDLY CHALLENGE. Perhaps the competition between the U. S. and the U. S. S. R. in the field of technology could be diverted to accommodate a new "race" in which the consequences for the loser are less ominous. This thought came to us with the announcement of the recent development in the U. S. of an electronic chess-playing computer, the third and most sophisticated of its kind yet developed, that is capable of giving a "fairly good player" a battle. The Russians, too, have developed a machine of equal merit, so . . . our machine will play your machine, Ivan—just name the date.

CHECK LIST FOR SPECIAL CABLE. As an aid to the engineer who has to design and use special electronic cables, we've printed the following check list which summarizes the desired requirements. Copies of this check list as a Cable Procurement Information Form will be sent at your request if you write to IMPULSE, c/o Rome Cable Corp., Dept. 1212, Rome, N. Y. When writing, ask for Bulletin RCD-400, a summary of special instrumentation cables available from Rome.

Number of conductors . . . conductor's size and stranding . . . desired insulation . . . shielding . . . outer covering . . . desired cable construction . . . maximum and minimum O.D. . . . upper operating-temperature limit . . . lower operating-temperature limit . . . bending radius desired . . . type of duty . . . electrical characteristics . . . special requirements . . . desired shipping lengths . . . specifications.

CABLEMAN'S CORNER. An important phase in multi-conductor cable manufacture is the manner and equipment used to "cable," or "twist," the various components together. The end use of the cable becomes an important factor in the assembly of a cable. Where flexibility is important, the length of lay, direction of lay, and the internal components all play important roles. Where connector fittings are employed, the sequential arrangement of the components may be important. Because of differing machine capabilities, even the selection of the specific piece of equipment for assembling your cable becomes important. To obtain the best results, consult a cable specialist—a man familiar with all the aspects of cable manufacture—your Rome Cable salesman.

These news items represent a digest of information found in many of the publications and periodicals of the electronics industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request. (13)

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 138A)

conditions; no load to full load, ±10% variation in line voltage and/or ±10°C temperature change. Recovery time for a 20 per cent load change is 100 microseconds. Voltage is adjustable with an accuracy of ±0.1%. Output voltage ripple is under 0.05%.

Units are packaged for mounting in standard 19-inch relay racks. They require 8¾" of rack space and are 23" deep.

Two models are offered. Model 1101 provides voltages from one to 999 volts in one-volt steps. Output current capacity is 100 milliamperes from one to 100 volts; 10 ma from 101 to 999 volts. Model 1102 provides voltages from 0.1 to 50 in 0.1-volt steps. Its current capacity is 15 amperes at all voltages.

Core Design Data

G-L precision-made, tape wound cores can now be obtained in two new core materials to precise limits and these materials and limits are illustrated and described in a new, 8-page, two color, illustrated catalog recently issued by **G-L Electronics,** 2921 Admiral Wilson Blvd., Camden 5, N. J. Data is included on SUPER HYMU "80" and SILICON Steel cores as well as on "O" ORTHONIK, "H" HYMU "80" and "B" HYMU "80" core materials. Core design data is included, as well as new case sizes. Bulletin TB-105 has diagrams, charts and tables which show the new test limits to precise ranges, constant-current flux-reset data and standard core sizes, and information on G-L matched cores, protective boxes and vibration and shock protection is supplied together with details on how to order.

"M" SUPER HYMU "80" is described as a vacuum melted material similar, chemically, to HYMU "80", but highly refined and carefully processed to produce initial permeability and dynamic core loss considerably beyond the possibilities of "B" HYMU "80" material; "S" SILICON Steel as a grain oriented, 3% silicon, 97% iron alloy which has a rectangular hysteresis loop.

For a free copy of Bulletin TB-105, write to the firm.

Spectrum Analyzer

The Federal Scientific Corp., 615 W. 131st St., New York 27, N. Y., announces a line of real-time Simoramic (tradename) spectrum analyzers. The analyzer synthesizes the equivalent of thousands of bandpass filters located side by side in the frequency domain through the use of a single delay line in a well-controlled closed loop. The frequency location, impulsive response, and gain of all the synthesized filters are determined by the same network elements within the closed loop, making for excellent reliability and stability. The

(Continued on page 142A)

New from Japan . . .

Important advance in short-haul, multi-channel communications

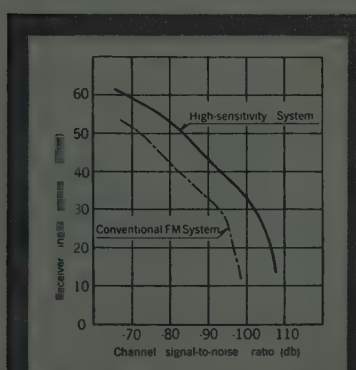
Microwave 60-channel voice transmission over a non-optical path up to 300 MILES is now possible without repeater stations.

NEC's High Sensitivity Reception System, by extending threshold level and improving S/N ratio 10 to 13 db, makes this hop with only 1/20 of the power output required for conventional systems.

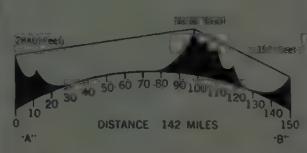
A 100 W transmitter in the 1,800-mc band, for example, has a scatter path of 100—150 MILES. A conventional FM system requires 2 KW output and at least one repeater station to connect the same distance over a non-optical path.

By eliminating high-power amplifiers and repeater stations, the High Sensitivity Reception System results in considerable reduction in initial investment. Savings in maintenance and power consumption are estimated at 40% or more.

Extensive propagation tests have been made, and NEC is now prepared to supply commercial users and government agencies anywhere in the world. Please write for detailed information.



CURVE compares receiver performance of High Sensitivity Reception System to conventional FM.



PROFILE shows how a 100 W transmitter operating at 1,920 mc connects a non-optical distance of 142 MILES in one hop. Average receiver input level is -75 dbm.

NEC

Nippon Electric Company Ltd.

Tokyo, Japan

Electronics / Communications Systems

Another Carad high power, high reliability Pulse Transformer is about to be put into service. Carad Transformer No. 809B, like all Carad pulse components, has been tailored to meet specific application objectives. It is one of a series of Pulse Transformers that range in voltage values from 100,000 to 400,000 volts, and with pulse widths from .5 to 30 microseconds. | 809B Output Parameters: Peak E, KV 150, Peak I, Amps 145, Peak P, MW 22., Load Z, Ohms ±10% 1030, Pulse Width, us 1 to 5, Rise Time, us .4, Fall Time, us 1.0, Droop at max. Pulse Width 3%, Overshoot 3% max., Backswing 18% max., Repetition Rate 600 PPS, Avg. Power, KWatts 66. Input Parameters: Turns Ratio Pri-to-Sec 1:11, Peak E, KV 13.7, Peak I, Amps 1600, Impedance, Ohms 8.5. General: Type of Sec. Winding Monofilar, Max. Ambient Temp. 50°C, Size: Transformer 21"x10"x14¾" H, Base Plate 25"x12"x½" Thick, Weight: 122 Pounds

CD

CARAD CORPORATION

2850 Bay Road • Redwood City • California

DESIGNERS AND MANUFACTURERS OF PULSE COMPONENTS AND SYSTEMS

NEWS New Products

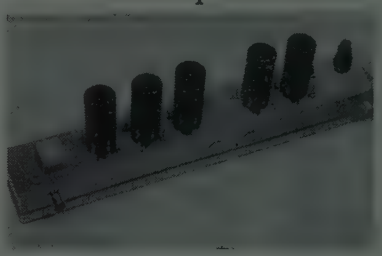
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 140A)

outputs of the individual synthesized filters are presented sequentially for either human observation or computer consumption.

The Model 4A analyzer covers the frequency band 1 cps to 200 cps with approximately 1 cps resolution. In conjunction with attachment FC4A the 200 cps frequency coverage range of the instrument may be positioned anywhere in the 1 cps to 10 kc frequency range.

IF Amplifier



LEL, Inc., 380 Oak St., Copiague, L. I., N. Y., has introduced a new addition to their IF amplifier line which extends the range of their standard cataloged units to 200 mc. The IF 39 has a gain of 120 db, 3 mc bandwidth, 200 mc center frequency, detector output, and provision for gain control. A matched input noise figure of 6.5 db is standard; lower noise figure input circuitry can be supplied if required. For further information contact the firm.

Transistorized Flip Flops

MF Electronics Co., 122 E. 25th St., New York 10, N. Y., announces a new line of packaged transistorized Flip Flops and Binary Dividers.

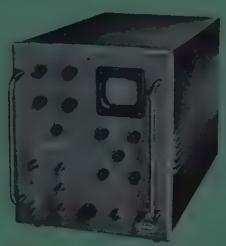
Designated our Types 24 through 27, these units are designed for high reliability operations and are available in speeds up to 1.2 mc. They are epoxy resin filled and can be furnished with either soft wire inline leads or solder hook terminals. The soft wire units are ideal for assembling on a printed wiring board, while the solder

(Continued on page 146A)

VISUAL MICROWAVE ANALYSIS–10 to 44,000 mc

COMPLEX SPECTRUM DECODING

Dissect complex pulse spectrum visually by means of Polarad Model SD-1



MULTI-PULSE SPECTRUM SELECTOR

Used with any Polarad analyzer, this Model SD-1 Spectrum Selector permits complete analysis of any complex pulse modulated microwave signals. The unit decodes and isolates any segment of a complex pulse train and permits corresponding spectrum analysis of that segment.

Model SD-1 Spectrum Selector displays pulse groups up to 180 microseconds duration (Model SD-1X: 350 microseconds).

Applications:

Design and operation of radar, telemetry equipment, IFF systems and beacons.

Analyze complex spectrum visually using any of Polarad's wide band

MICROWAVE ANALYZERS

Model TSA Spectrum Analyzer —25 kc resolution, 400 kc to 25 mc dispersion. 5 sensitive plug-in tuning units.

Model TSA-S Combination Synchroscope-Spectrum Analyzer —Displays pulse waveform or frequency spectrum. 5 kc to 5 mc adjustable bandwidth, 400 kc to 25 mc dispersion. 5 sensitive plug-in tuning units.

Model TSA-W Wide Dispersion Spectrum Analyzer —100 kc to 70 mc dispersion. 7 kc and 50 kc resolution. Logarithmic amplitude display. 5 sensitive plug-in tuning units.

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Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Handbook of Spectrum Analyzer Techniques" and "Notes on Microwave Measurements"

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POLARAD

- ☐ Model SD-1 Multi-Pulse Spectrum Selector
- ☐ Microwave Spectrum Analyzers
- ☐ Model B Microwave Code Generator (see reverse side of this page)

My application is:_____

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APPLICATIONS:

One integrated instrument:

Provides a complete system for simulating and testing missile and telemetry systems, IFF and radar, microwave beacons, direction finding and navigational equipment and microwave relay links.

Performs general purpose signal generator and oscilloscope measurements, multi-pulse testing and analysis.

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Frequency range 950 to 10,750 mc is covered by four interchangeable microwave oscillator units, all stored in the instrument. Each has UNI-DIAL control, precision power monitor circuit to maintain 1 milliwatt power output reference level, and non-contacting short-type chokes to assure long life.

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Calibration of r-f pulse width, delay and group repetition rate is simplified by ability to view pulse train on a precision oscilloscope with a built-in wide band r-f detector.

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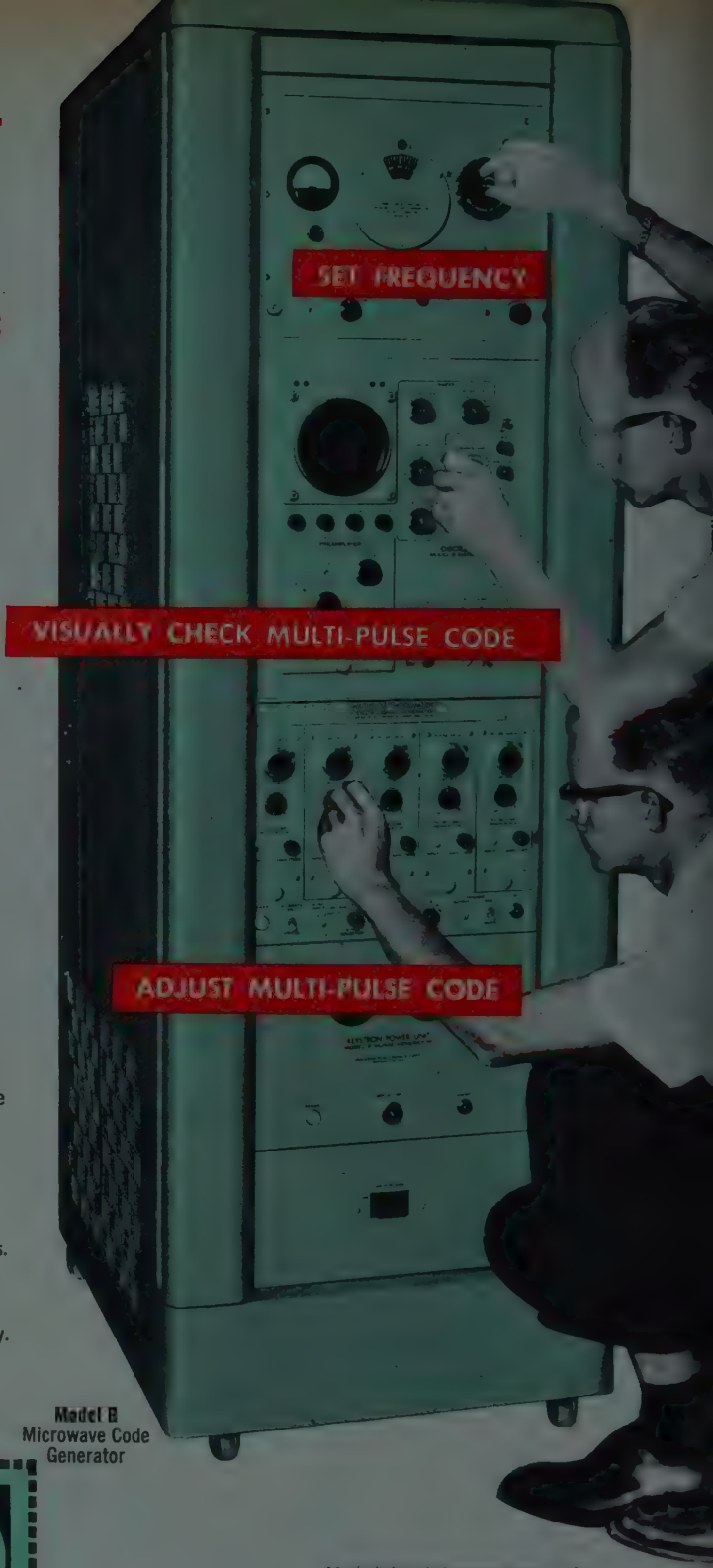
Code modulation is achieved with five independently adjustable pulse channels providing: **pulse repetition rate** variable, 10-10,000 pps; **width** variable 0.2 to 2 microseconds; **delay** variable 0-300 microseconds. **Pulse rise and decay,** 0.1 microsecond.

NO ADJUSTMENT NECESSARY on self-contained power supplies. Klystron power unit adjusts to proper voltage automatically for each interchangeable tuning unit. Built-in AC regulator. Equipped with an electronically regulated low-voltage DC supply.



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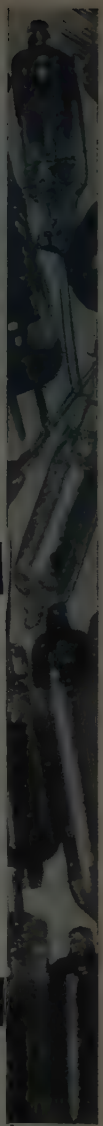

VOLTAGE REGULATOR TUBES

Type	Base	D.C. Operating Voltage	Current Range	Regulation
OA2WA **CK6626/OA2WA** **CK6073, OA2**	Miniature	150 v.	5 — 30 ma.	2 v.
OB2WA **CK6627/OB2WA** **CK6074, OB2**	Miniature	105 v.	5 — 30 ma.	1 v.
OC2	Miniature	75 v.	5 — 30 ma.	3 v.
CK5787	Subminiature	98 v.	5 — 25 ma.	3 v.
CK5787WA	Subminiature	98 v.	5 — 25 ma.	1.5 v.
CK6542	Subminiature	148 v.	5 — 25 ma.	2 v.
Corona Voltage Regulators				
CK1038	Subminiature	885 — 915 v.	5 — 55 μa.	15 v. max.
CK5962	Miniature	700 v.	2 — 55 μa.	15 v. max.
CK6437	Subminiature	700 v.	5 — 125 μa.	15 v. max.
CK6438	Subminiature	1200 v.	5 — 125 μa.	20 v. max.

VOLTAGE REFERENCE TUBES

Type	Base	D.C. Operating Voltage	Current Range	Regulation	Voltage Jump Max.
CK5651	Miniature	85 v.	1.5 — 3.5 ma.	1.5 v.	0.1 v.
CK5651WA	Miniature	85 v.	1.5 — 3.5 ma.	1.5 v.	0.005 v.
CK5783	Subminiature	85 v.	1.5 — 3.5 ma.	3.0 v.	0.1 v.
CK5783WA	Subminiature	85 v.	1.5 — 3.5 ma.	2.4 v.	0.005 v.
CK6213	Subminiature	130 v.	1.0 — 2.5 ma.	1.0 v.	—

COLD CATHODE RECTIFIER TUBES

Type	Construction	Base	Max. Peak Inverse Voltage	Peak Plate Current	Max. D.C. Output Current
OZ4A/1003	Double Diode	Octal	880 v.	330 ma.	110 ma.
CK1005	Double Diode	Octal	450 v.	210 ma.	70 ma.
CK1006	Double Diode	4 Pin.	1600 v.	600 ma.	200 ma.
CK1007	Double Diode	Octal	1200 v.	510 ma.	85 ma.
CK5517	Diode	Miniature	2800 v.	100 ma.	12 ma.
CK6174	Diode	Miniature	2800 v.	30 ma.	3 ma.
CK6659	Diode	Subminiature	2800 v.	40 ma.	8 ma.
CK6763	Diode	Miniature	2800 v.	100 ma.	12 ma.

Detailed technical data bulletins on any of these types are yours for the asking. Better yet, ask to have a Raytheon sales engineer drop in for a firsthand appraisal of your application and prototype needs — no obligation, of course. Write directly to Dept. 2528.

Small order and prototype quantities available directly from your local Raytheon electronics parts distributors.

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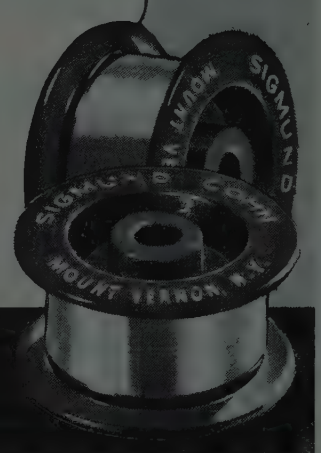

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NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 142A)

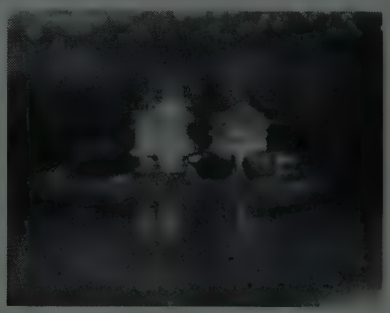
hook terminal units may be wired from point to point.

All units operate up to 60°C and are designed to meet the requirements of MIL-T-21038, Grade 5, Class Q, Life Expectancy X, with respect to materials, workmanship and general design features.

4,000-MC Esaki-Diode Oscillator

One of the most interesting semiconductor devices to come along in recent years is the Esaki or tunnel diode. High frequency response, low noise figure, ability to operate from near absolute zero to several hundred degrees centigrade and remarkable resistance to radiation damage are some of its features.

International Business Machines Corp., 590 Madison Ave., New York 22, N. Y., has done considerable experimental and theoretical work in investigating the Esaki diode or tunnel diode as a possible computer component. One result of this research effort is reported in an article by R. F. Rutz in the October issue of the IBM Journal of Research and Development.



Greatly magnified view of the "heart" of the Esaki-diode oscillator. At left is the germanium resistor. At right is the highly etched Esaki diode. Its narrowest dimension is about 0.001 inch.

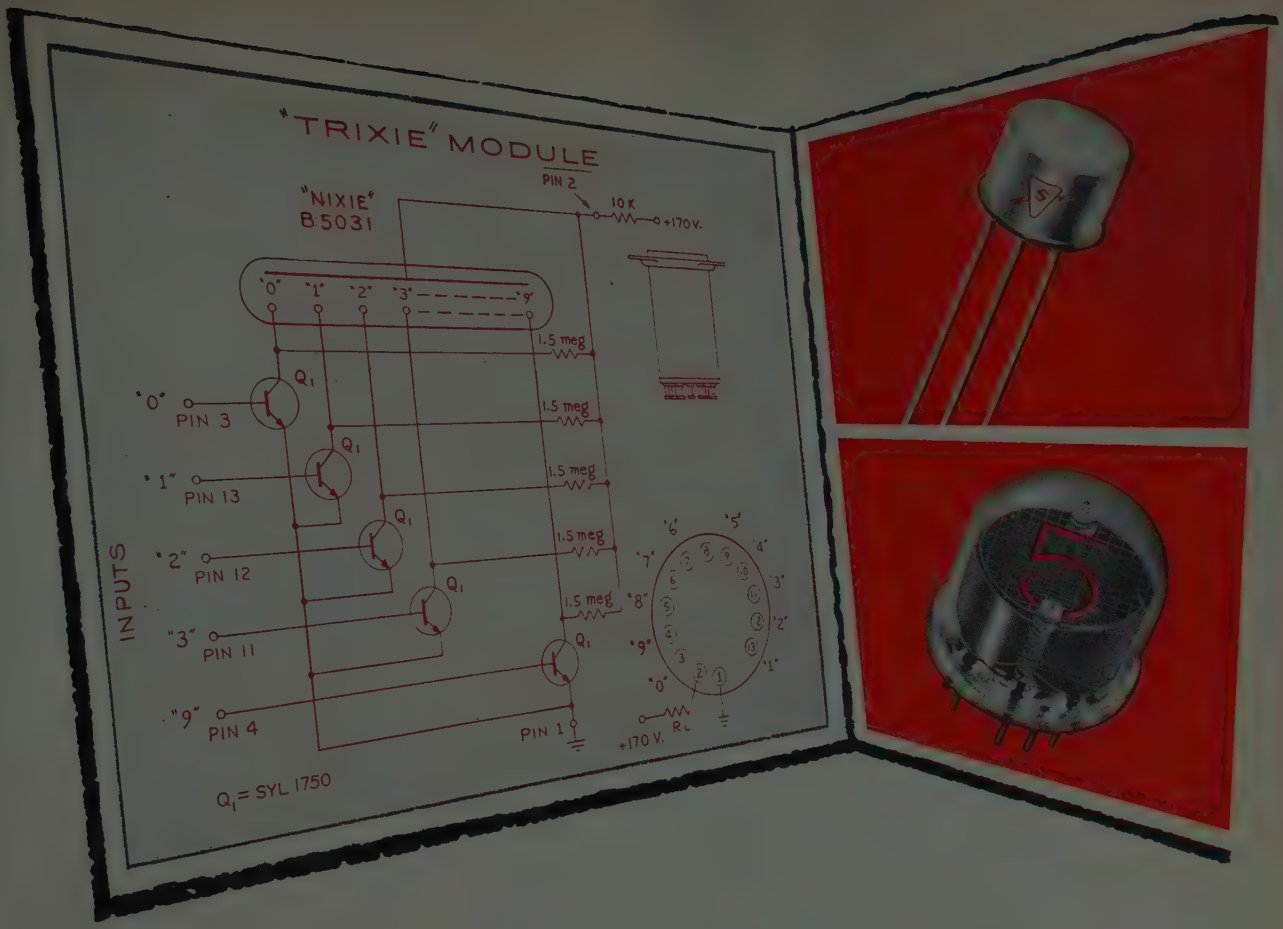
Two significant factors in this development* should be noted. First, an experimental oscillator has been fabricated from germanium with a fundamental frequency of oscillation of 3,010 mc. (A more recent model, however, has a fundamental frequency of oscillation of 4,020 mc.) These are believed to be the highest frequencies of oscillation for Esaki-diode oscillators yet reported. The high-frequency limit of the oscillator design is not known. Second, the design approach is non-conventional in that no cavities are used as tuned elements. Instead, the design is one using "lumped parameter" components, (inductance, capacitance and resistance).

Complete technical details on the design of the oscillator are given in the article.

A second article by P. J. Price and J. M. Radcliffe, in the same issue, reports on investigation of the fundamental theory of "Esaki Tunneling."

* This work was supported by the Department of Defense.

(Continued on page 148A)



...NEW LOW-COST

Transistorized Readout

"Trixie", new computer readout circuit design, utilizes Sylvania's new NPN transistor, Syl 1750, and the Nixie® indicator tube

Now, designers can meet direct readout requirements for computers, instrumentation and data display with new economy and efficiency. Sylvania, pioneer manufacturer of NPN transistors, has developed new parameters in the Syl 1750 to meet the need for a low voltage input driving circuit for the Nixie indicator tube.

"Trixie" (Transistors + Nixie tube) comprises ten Sylvania NPN medium voltage switching transistors, Syl 1750, in a common emitter configuration. Each transistor drives one of the tube's ten cathodes. The result is the lowest power visual readout available. It can be designed in plug-in module form around a standard Nixie tube socket with terminals provided for electrical connections. A typical module, especially adaptable for direct panel mounting, has an over-all length of two inches and a nominal one-inch diameter.

The new Syl 1750, specially designed for "Trixie," is a 40 v (minimum) NPN germanium alloy junction transistor. Its low cost is a product of Sylvania's production know-how in NPN transistor manufacture and long experience in NPN design. Syl 1750 meets the reliability and performance criteria of other Sylvania switching transistors and matches their high-quality standards. It is encased in a JEDEC TO-5 package with the Sylvania welded hermetic seal for full protection against humidity and other environmental conditions.

Call your Sylvania representative now for full details of the new low-cost transistorized readout components.

"Trixie" & "Nixie" are trade marks owned by Burroughs Corporation.

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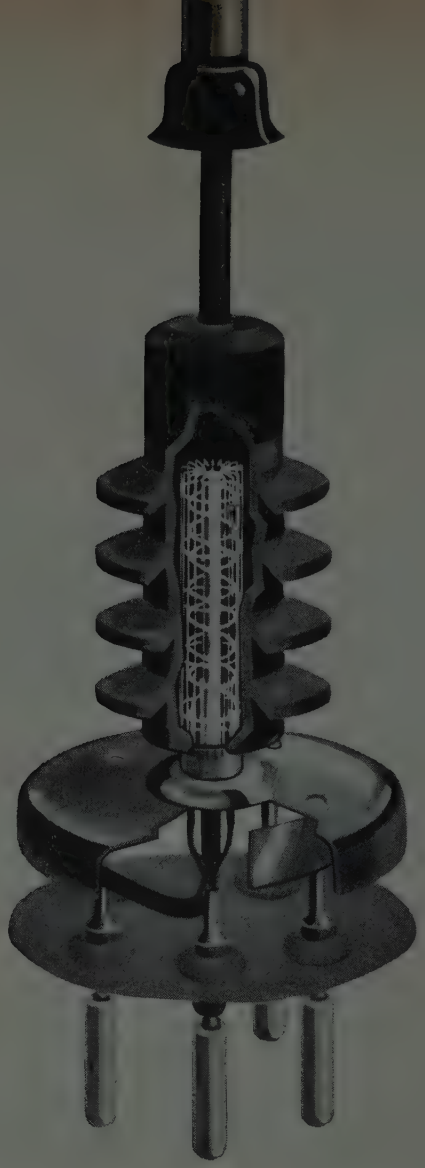

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From the simplest tube element to the most complex tube configuration, from research to installation, it can be said that the entire Amperex effort is dedicated to the development of outstanding new types and improvement of existing tubes.

Research and development facilities—world-wide and virtually unlimited in scope—are fully utilized, both for the purpose of creating these improvements and for creating those exclusive Amperex manufacturing techniques that have come to signify "hand-made" quality in mass production quantities.

Amperex tubes and semiconductors are presently adding to the stature of the 30 year old Amperex name in such fields as Nuclear Instrumentation, Advanced Military Electronics, Mobile Communications, Computers, Induction and Dielectric Heating, Ultrasonic Cleaning, Radio and TV Broadcasting and Entertainment.

A modern, well-equipped Application Engineering Department is available for the assistance of customers who are concerned with circuit and application problems relating to tubes. Write to Amperex Electronic Corp., 230 Duffy Avenue, Hicksville, L. I., N. Y.

ask Amperex®
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NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 146A)

Ewen Knight Has New Plant

More than three hundred attended official dedication ceremonies, on Tuesday, of the **Ewen Knight Corporation's** new installation at Cerel-Perini's East Natic, Industrial Park, East Natick, Mass.

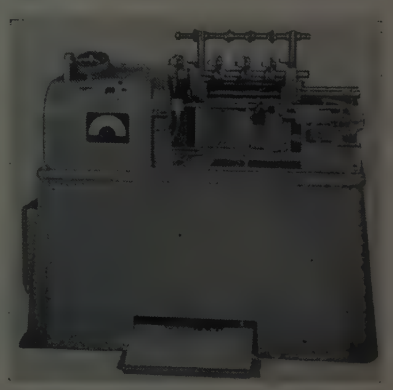
Following the presentation, guests were taken on a guided tour of the new facilities and were shown the technical equipment being produced at the laboratory, both for government and private industry. The very sensitive (low internal noise) receivers and radiometers are used to receive signals from other planets, the sun, moon and stars. These signals give indications as to the nature of other planets, their surrounding atmosphere and distance and motion of the celestial body in relation to the earth.

Open House guests were shown the firm's process for producing synthetic rubies which are used in their latest low noise receiving equipment.

Various groups also viewed Maser Systems, all types of ferrite devices, low-internal noise receiver systems and other advanced projects being developed at the new laboratory.

Multiple Transformer and Bobbin Winder

A new multiple transformer/bobbin winder which eliminates gear changes and permits rapid change-over from one wire gauge to another is now available from **Geo. Stevens Mfg. Co., Inc.**, Pulaski Road at Peterson, Chicago 46, Ill.



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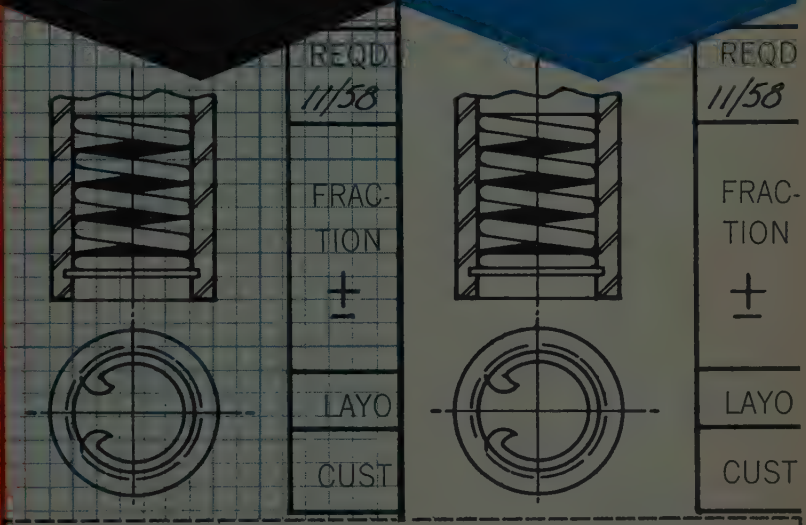

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ESSE RADIO COMPANY, Dept. D9
42 W. South Street **Indianapolis 25, Indiana**

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 148A)

Model 500-AM winds power, audio and similar types of heavy duty transformer coils and all types of heavy duty field coils and bobbins. Complete transformers may be wound without removing mandrels from machine. Dial is calibrated in wire sizes from 10 to 31 AWG, permitting instant selection of correct winding pitch. Machine also handles wire finer than 31. Maximum coil OD is 16", maximum winding stroke 9", maximum loading distance for multiple winding 24" and winding range from 5 through 100 turns-per-inch on calibrated dial and up to 450 turns-per-inch uncalibrated. Winding width is instantly adjusted by moving slider on claibrated scale to desired winding width. Machine is furnished with instant re-set automatic counter, magnetic brake, instant spiral/rapid traverse, motor and heavy duty tailstock. Winding speeds are up to 380 RPM. Machine is also available as Model 500, without automatic counter and without magnetic brake but with heavy duty positive locking tailstock and dial counter.

Infrared Standard

The ISL 403 Black Body with the ISL 100 Temperature Controller represents an accurately adjustable standard of radiant energy which checks and calibrates other infrared sources and measuring instruments.

Designed to emit black body radiation over the temperature range of 500°K to 1000°K, the stability of its operation is such that the radiation source temperature is maintained within ±1°K despite wide changes in ambient temperature, line voltage variations, transients and tube aging.

The ISL 403 is maintained at the selected temperature by a combination of vacuum-tube amplifier and thyratron circuitry in a power-proportioning temperature controller of high performance.

Write today for ISL Bulletin #2 and more complete specifications to: **Infrared Standards Laboratory,** 10555 Magnolia Ave., Riverside, Calif.

(Continued on page 154A)

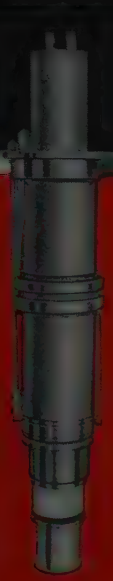
A few of Varian's large research team on wave tubes confer on new design features

TOP TEAM IN WAVE TUBES

Varian has become the world's leader in the development and production of microwave tubes. With a greatly expanded wave tube team and larger manufacturing facilities, new tubes for advanced applications are being offered at an accelerated pace. From the small X-Band BWO's to the megawatt TWT, there is a Varian wave tube to meet your requirements.

Over 100 Varian Klystrons and Wave Tubes are pictured and described in our new catalog. Write for copy—address Tube Division.

VA-125A, B TWT	2.65 to 3.25 kMc 2 megawatts peak output
VA-161 BWO	8.2 to 12.4 kMc
VA-162 BWO	12.4 to 18.0 kMc
VA-128 TWT	2.6 to 3.4 kMc 10 kw peak output



VA-125A, B TWT

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VA 161
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BWO's

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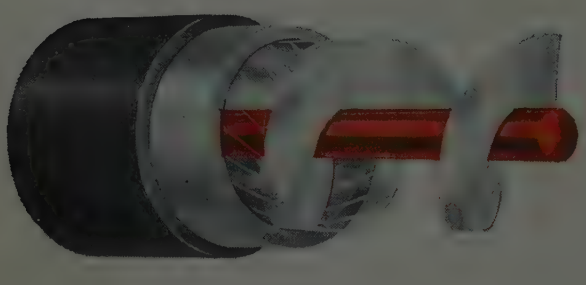

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in the free world. Separate cable length
connect each of the 120 vertical antenna
with a laboratory in the circular installatio
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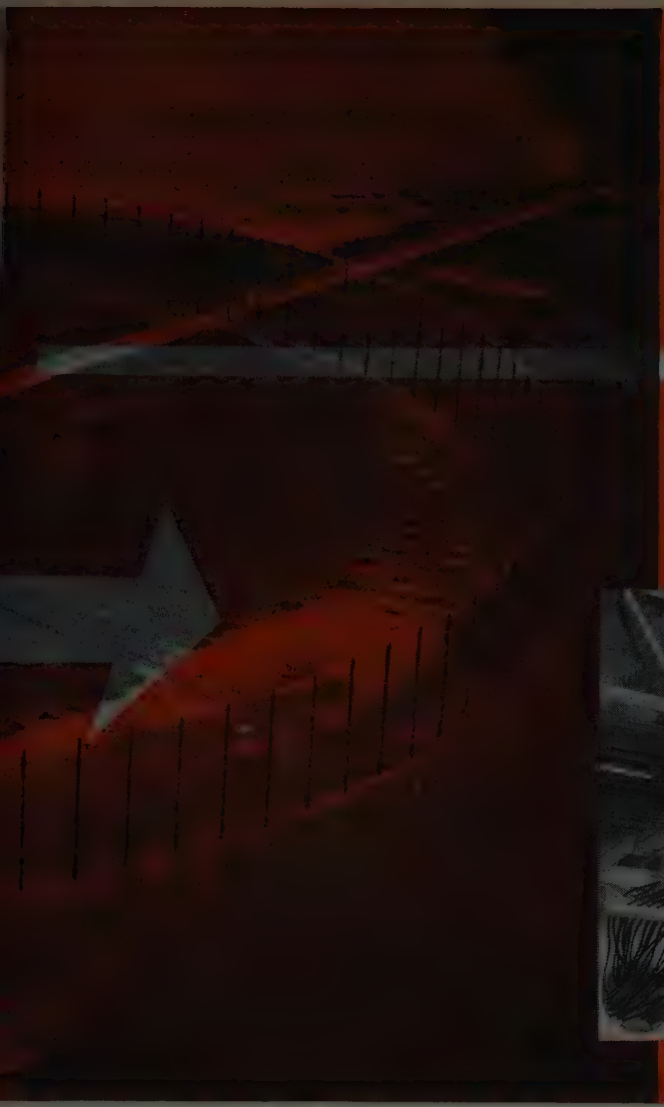

Gigantic radio direction finder has 120 poles, each 65 feet high, supporting a screen of 1,200 vertical wires, two feet apart. Outside the screen are 120 vertical antennas, each 15 feet high, set on concrete pedestals in a 955-foot circle. Installation covers 40 acres.

Styroflex® coaxial cables from antennas are shown entering laboratory through side walls. Signals are fed into laboratory via these cables.

role in Free World's largest radio direction finder

near its Urbana-Champaign campus.

The huge direction finder was installed by the University of Illinois in cooperation with the Federal Telecommunications Laboratories under the sponsorship of the Navy Bureau of Ships. Its purpose is to develop improved radio direction finding techniques, including equipment design and operation.

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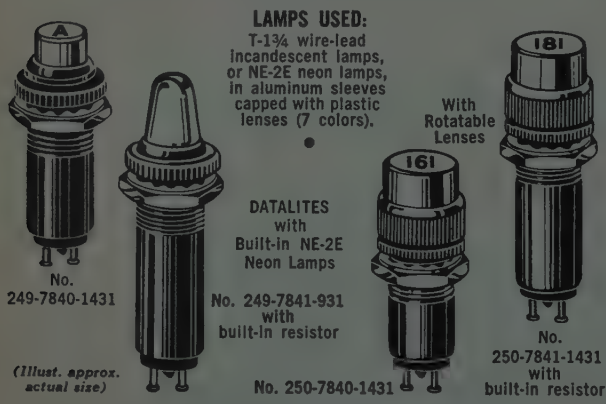
In this brochure—complete facts on DIALCO's

DATALITES®

For the Computer-Automation Industries

DATALITES by DIALCO are ultra-miniature Indicator Lights specially designed to meet the critical requirements of the computer-automation fields. Made in 2 basic styles: *Lamp Holders with* DIALCO'S own *replaceable Lamp Cartridges* (see above); or integrated DATALITES *with Built-in Neon Lamps* which are *not replaceable* (see below). Ultra-compact, single units mount in ⅜" clearance hole; the twin-lamp assembly mounts in ¾" clearance hole.


LAMPS USED:
T-1¾ wire-lead incandescent lamps, or NE-2E neon lamps, in aluminum sleeves capped with plastic lenses (7 colors).
With Rotatable Lenses
DATALITES with Built-in NE-2E Neon Lamps
No. 249-7840-1431
No. 249-7841-931 with built-in resistor
No. 250-7840-1431
No. 250-7841-1431 with built-in resistor
(Illust. approx. actual size)

DATALITES have fully insulated terminals and conform to all applicable military specifications. Integrated units are available *with or without built-in resistors.* The cylindrical lenses can be hot-stamped with digits, letters, etc. Complete details in *Brochure L-160A.* Send for it now.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

60 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 150A)

Dynamic Gear Opens New $250,000 Plant in Amityville, N. Y.

Dynamic Gear Co., which began operations in 1948 in a barn in Brooklyn, opened a new $250,000 plant in Amityville, N. Y. last month. The firm's president William A. Wiegand was formerly employed by W. L. Maxson Corp. This was during the period when Maxson was one of a limited number of firms which produced precision gears. Nine months before leaving Maxson, Wiegand formed his own firm and handled it on week-end and part time basis. His original investment at this point was $2,000.

One of Wiegand's innovations was to design a standard line of precision miniature gears available from stock. An engineer who needed a precision gear of this type formerly had to draw the specifications, request a bid and on acceptance wait for delivery. Dynamic's stock gears could be sold at 1/15 of the custom price. His delivery time was four or five days. The original line of off-the-shelf items was 40 types, the present line is over 12,000.

Many private firms are currently using Dynamic's gears, but his big customers are firms doing business with the military. Here they are used in 3 different missiles, and inertial guidance systems in two new submarines.

Typical of the firm's diverse line of products is a miniature 15 speed transmission.

The 15 precisely controlled speeds range from 3.3 RPM to 7812 RPM is electronically controlled by the use of magnetic clutches with desired speeds obtained by dialing. No manual shifting of gears is necessary.

Case dimensions of this transmission, excluding power source and control panel, measures $4\frac{1}{2}$" in width, $7\frac{1}{2}$" in length and is $3\frac{5}{8}$" high. Torque developed at the various speeds range from 50 to over 100 oz./in. The magnetic clutches are rugged construction and designed to offer years of satisfactory operation.

All gears and shafts used in the transmission are part of the Dynaco line and constructed of either #303 stainless steel or 24 ST aluminum which, in addition to the housing, offer resistance to corrosion.

The input motor is reversible and will deliver the above speeds and respective torque in either direction. The motor speed is self-governed and maintained at 8,500 RPM. Units operate on 115 volts, 60 or 400 cps current.

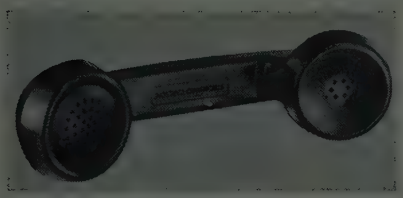
Typical applications of Dynamic Gear's 15-speed transmission, presently in the prototype stage, are for recording instruments such as oscillographs and other recording devices requring constant and precise speeds. It can also be used as a laboratory device for testing servo packages.

(Continued on page 156A)

for your voice communications

STROMBERG-CARLSON TELEPHONE HANDSETS

MODELS FOR MANY INDUSTRIAL APPLICATIONS



No. 26: short, lightweight, sturdy. Comes with capsule-type receiver and transmitter.

No. 27: high-gain version of No. 26 handset.

No. 28: "push-to-talk" handset. Rocker bar switch; various spring combinations.

No. 29: high-gain version of No. 28 handset.

Typical applications: mobile radio • intercom systems • carrier and microwave • aircraft and railroad.

Modern handset cradle for mobile or panel use fits any Stromberg-Carlson handset.

Send for Bulletins T-5005 and T-5013. Write to Telecommunication Industrial Sales, 115 Carlson Road, Rochester 3, New York.

STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS

SPACE COMMUNICATION ANTENNAS

ANDREW

Quad-Helix antenna

tracks long and medium-range missiles

Telemetry circuits between missile (or satellite) and ground station are reliably maintained with the ANDREW Quad-Helix Array. This system offers low VSWR, high gain, and easy control.

Gain is 17.5 db at 265 mc, 14.5 db at 215 mc. VSWR is less than 2.0:1 across this range. Polarization is right hand circular; impedance 50 ohms. Counterbalanced rotator provides 180° elevation and 720° azimuth tracking at speeds from 0° to 30° per second.

Optional remote control unit regulates speed and direction.

OTHER ANDREW GROUND-AIR ANTENNAS

TRI-HELIX ANTENNA

880-990 MC 17.5 DB GAIN TYPE 81068

HELIX ANTENNAS

FREQUENCY	GAIN	TYPE NUMBER
108-132 mc	12 db	H 19110 A-1
215-265 mc	10.5 db	H 50140 A
215-265 mc	13 db	H 19110 A-2
260-320 mc	13 db	H 19110 A-3
320-400 mc	13 db	H 19110 A-4
400-500 mc	12 db	H 19110 A-5

DISCONE ANTENNAS

FREQUENCY	TYPE NUMBER
25-50 mc	50154
50-108 mc	51150
108-215 mc	19050-1
215-420 mc	19050-2
420-1000 mc	19050-3

For full information on these and other ANDREW ground-air antennas, write today for Bulletin 8456

Andrew CORPORATION

363 EAST 75th STREET • CHICAGO 19

Offices: New York • Boston • Los Angeles
Washington, D.C. • Toronto

2N416
2N417
2N425
2N426
2N427
2N428

Specify with assurance when you specify

INDUSTRO

alloy junction germanium

PNP TRANSISTORS

Absolute reliability has been imperative in the Polaris. The extreme reliability designed into the Polaris Missile Program requires transistors which far exceed the operating and environmental conditions of MIL-T-19500A.

Industro is proud of its contribution to the success of this vital military project.

Whether your transistor requirements are military or commercial you can depend on Industro. We invite your inquiries.

INDUSTRO

35-10 36th Avenue • L. I. C. 6, N. Y.
IN CANADA:
CANADIAN GENERAL ELECTRIC COMPANY LIMITED

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 154A)

Telemetering Oscillator

A new millivolt transistorized oscillator that reduces bulk and weight, lowers power demands, and eliminates a source of error, was announced by the **Hoover Electronics Co.**, Timonium, Md.

The new oscillator, developed by Hoover's engineering staff, makes it possible and advantageous, for the first time, to feed the output of low level transducers (such as thermocouples, strain gauges, accelerometers) directly into the Hoover subcarrier oscillator without dc amplification.

The new millivolt oscillator also has several characteristics which set it apart from earlier developments in the field, including dc common mode rejection and floating input terminals. The dc common mode rejection is conservatively rated at 10^7 within ± 20 volts of ground.

This permits the oscillator to be used with bridge circuits for measuring the voltage between two points in the bridge, without the oscillator's being affected by a voltage from one point to ground.

The floating input terminals eliminate problems which often result from a common ground among several components.

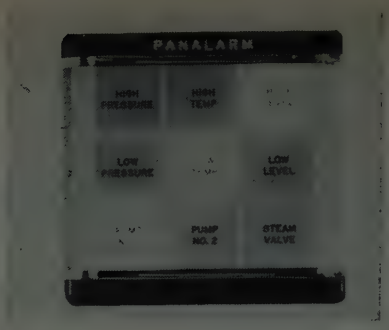
The subcarrier oscillator contains an internal voltage regulator. Its power requirement is +26 volts. The distortion of the output signal is limited to less than 1% by a bandpass filter which also prevents interference with adjacent channels.

The unit is produced to IRIG specifications of frequencies and deviations for channels 5 through 18 and A through E.

New Rep For Polyphase

Polyphase Instrument Co., E. Fourth St., Bridgeport, Montgomery Co., Pa., is pleased to announce the appointment of the J. S. Kempf Company, 10304 Praire Ave., Inglewood 2, California, as West Coast Sales Representative for the sales of its pulse and specialty transformers, electrical wave filters, and associated magnetic electronic components.

Solid State Annunciator



A new economical, solid state, miniature lo-drain, expandable, annunciator providing information and control of industrial process systems has been developed by **Panellit, Inc.**, 7401 No. Hamlin Ave., Skokie, Ill. The "Panastat" annunciator has longer life and greatly decreased maintenance because there are no moving parts. All operational functions are performed by highly derated solid state elements. Low energy control circuits (a tiny fraction of 1500 millijoules) and negligible inductance (considerably below 0.001 Henry) provide intrinsic safety. Ignition in hazardous atmospheres is impossible because no arc can be sustained. All Class I, Division II requirements are exceeded; there are no make or break contacts. The annunciator operates on standard ac or dc line voltages; no transformer power supply is required. Operation is not affected by normal line variations or surges. Continuous duty is maintained at $\pm 20\%$ nominal voltage. Lamps are interchangeable with existing annunciators. Models of this system can be expanded easily due to interchangeable plug-in units. Momentary field contact operation of 0.5 milliseconds is sufficient to lock-in the system and avoid alarm loss. The miniature annunciator can be supplied to fit a $5'' \times 5''$, $6'' \times 6''$ standard pneumatic or electronic instrument case or any standard annunciator cabinet.

Millimicrosecond Current Generators Catalog

Single catalog bulletin describes Model 3000A (2 channels) and Model 3010A (4 channels) which provide fast rise time, high power, current pulse outputs. Modular plug-in construction allows versatility of performance and application. For a copy contact **Electro-Pulse, Inc.**, 11861 Teale St., Culver City, Calif.

Precision Potentiometer Catalog

Electromath Corp., 115 Pleasant Ave., Roosevelt, L. I., N. Y., has 8 new catalog sheets describing their line of precision potentiometers. These include illustrations and specifications on single-turn trimmers, dual 10-turn, continuous single-turn, dual 3-turn, miniature single-turn, high temperature single-turn, high stability 3-turn, and high resolution 10-turn types.

(Continued on page 180A)

SENSITIVE RESEARCH

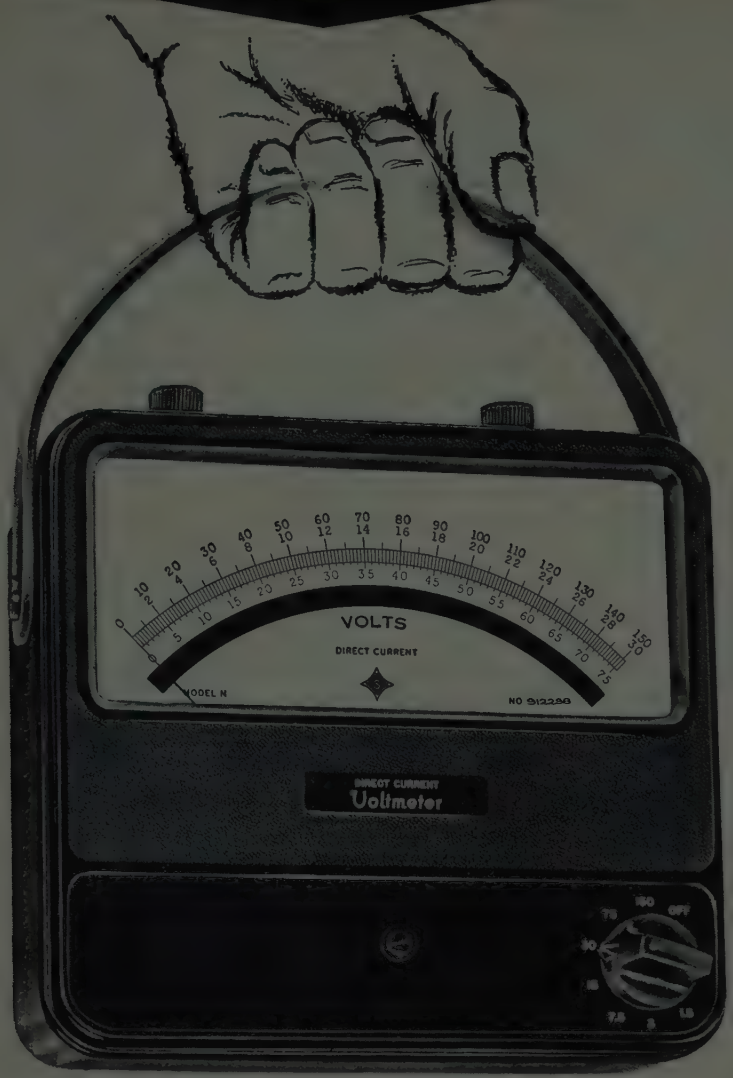
THE *New* MODEL "N"

A new series of AC and DC portable electrical indicating instruments — *that can also be panel mounted.*

A *New* HIGH in accuracy, resolution, and stability.

A *New* LOW in cost.

In short, the SRIC Model "N" series probably has just the instrument for which you've been looking HIGH and LOW. The Model "N" is a true "secondary standard" because it is engineered and manufactured by "standards people."



Model "N"

GENERAL SPECIFICATIONS:

Accuracy: .5% of full scale.

Scale: Hand-drawn and mirrored.

Scale length: 6".

Resolution: 100 to 150 division.

Ranges: DC from 50 ua. to 50 A. and 20 mv. to 1000 v. full scale. AC from 10 ma. to 10 A. and 7.5 v. to 750 v. full scale.

Availability: 1 to 8 ranges completely switch-controlled and self contained.

Construction: DC — double pivoted permanent magnet type. AC — moving iron vane for RMS measurements and germanium rectifier type for average reading measurements.

Shielding: Magnetic and electrostatic.

Pivots and Jewels: High carbon steel pivots and shock mounted sapphire jewels. (Diamond pivots available on special order).

Case: Black moulded bakelite with leather carrying handle. Size 7½" x 6¾" x 3½". Internal lighting avail.

The *New* Model "N" is a stable, rugged, versatile field or laboratory instrument that is *spectacular* because in every way it offers a little bit "more" than any other instrument in its class. It is available in standard range combinations or in quantities with special ranges and/or special scale markings.

The New* Model "N" *conforms to ASA specs. C 39.1-1951 for .5% class instruments. All SRIC instruments are calibrated against primary standards that have National Bureau of Standards Certificates of Accuracy and are unconditionally guaranteed for a period of one year.

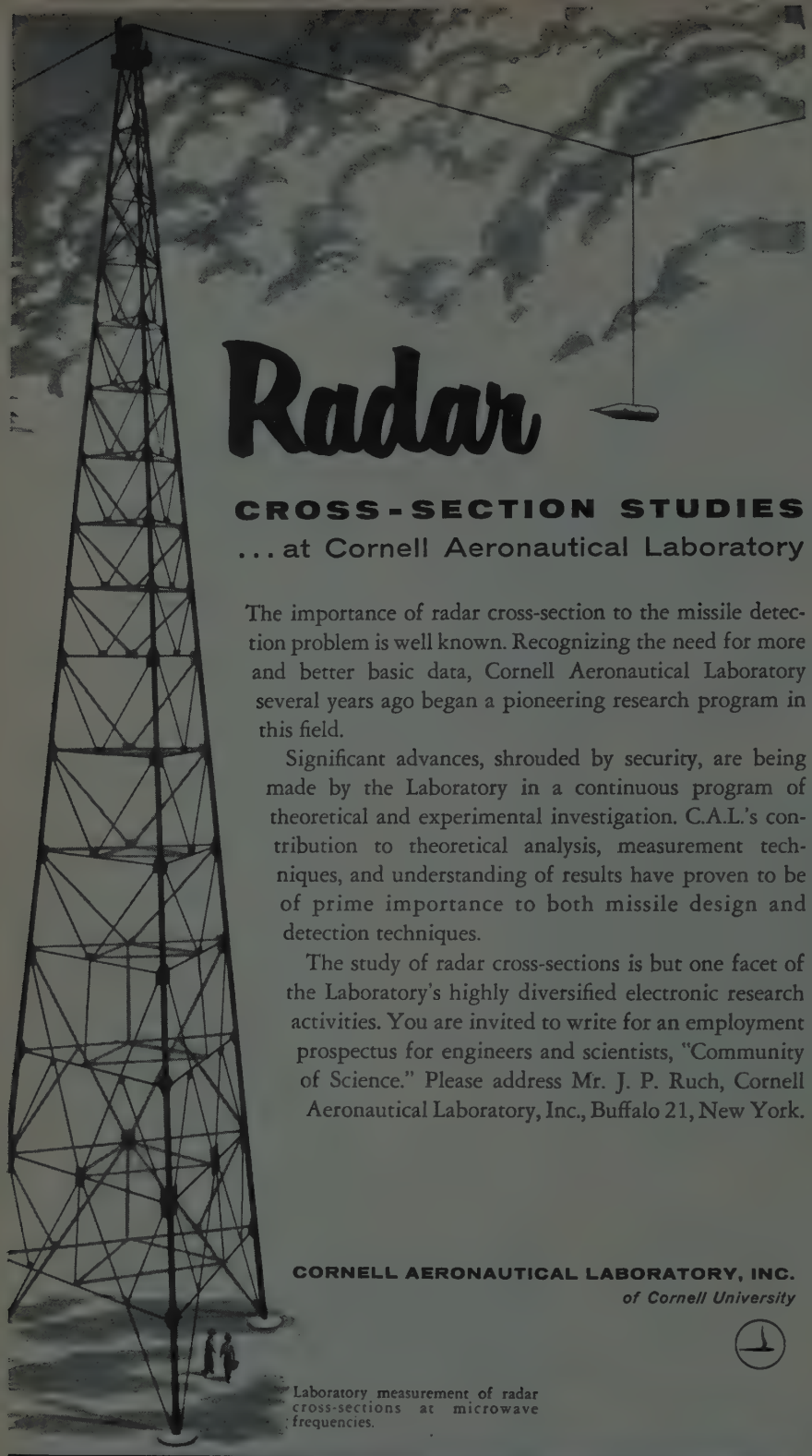
The movement construction shown features a large size U-shaped magnet with an inherently high torque-to-weight ratio, stability and sensitivity — and not the common center core magnet usually found in instruments in its price range.

AC INSTRUMENTS UTILIZE A FAST-ACTING, RUGGED, MOVING IRON-VANE MOVEMENT.

SENSITIVE RESEARCH INSTRUMENT CORPORATION

Symbol of Quality

NEW ROCHELLE, N. Y. ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1937



Radar

CROSS-SECTION STUDIES
... at Cornell Aeronautical Laboratory

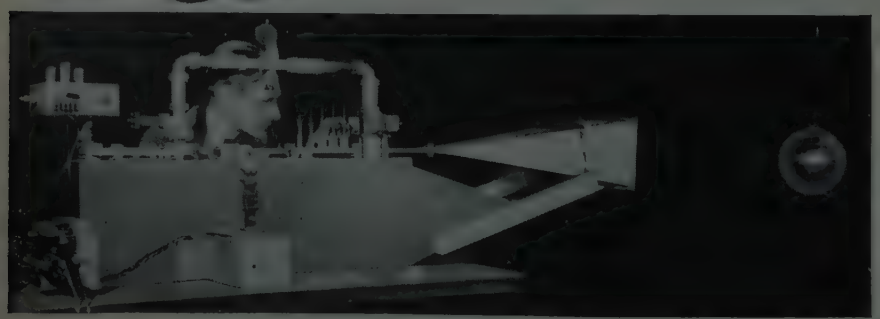
The importance of radar cross-section to the missile detection problem is well known. Recognizing the need for more and better basic data, Cornell Aeronautical Laboratory several years ago began a pioneering research program in this field.

Significant advances, shrouded by security, are being made by the Laboratory in a continuous program of theoretical and experimental investigation. C.A.L.'s contribution to theoretical analysis, measurement techniques, and understanding of results have proven to be of prime importance to both missile design and detection techniques.

The study of radar cross-sections is but one facet of the Laboratory's highly diversified electronic research activities. You are invited to write for an employment prospectus for engineers and scientists, "Community of Science." Please address Mr. J. P. Ruch, Cornell Aeronautical Laboratory, Inc., Buffalo 21, New York.

CORNELL AERONAUTICAL LABORATORY, INC.
of Cornell University

Laboratory measurement of radar cross-sections at microwave frequencies.



Positions Open

The following positions of interest to IRE members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. . . . .

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

Proceedings of the IRE
1 East 79th St., New York 21, N.Y.

ENGINEER

Unusual opportunity for creative engineer to perform challenging, diversified work with Long Island quality instrument mfg.-leader millimicrosecond techniques. Excellent salary and room for rapid growth in active, congenial and expanding company. Requirements: 5 years development experience in pulse, transistor and high frequency circuits. Must be capable of assuming product responsibility. Apply Lumatron Electronics, Inc., 68 Urban Ave., Westbury, N. Y. Tel. EDgewood 4-3100.

PROFESSOR AND ASSOCIATE PROFESSOR

Professor and Associate Professor of Electrical Engineering—to teach graduate and undergraduate subjects to participate in developing research program in a southern university. Good location in an industrial region. Competitive salaries for various levels of education and experience. Box 2003.

TEACHING—RESEARCH

The new Electrical Engineering Dept. at the University of Rochester is seeking to expand its staff, and has openings on its faculty for qualified electrical engineers and scientists interested in positions combining teaching and research responsibilities. Salary scales are fully competitive with other leading institutions, and are designed to interest people of the highest competence. Write, including resume, to Daniel W. Healy, Jr., Head, Dept. of Electrical Engineering, University of Rochester, Rochester 20, N. Y.

ELECTRONICS ENGINEER

Our company is setting up a new industrial electronic group and may have just the position you are seeking. We would like to engage a man capable in the application of electronic measuring and control systems to industrial processes. Prefer he be familiar with electrical laboratory test equipment and current in knowledge of available instrumentation. Knowledge of pulse techniques and transistor circuitry background would be very helpful. Reply immediately giving education, experience, age and salary expected. Box 2004.

TEACHING—ELECTRICAL—ENGINEERING

Additions to electrical engineering faculty desired by engineering school of midwestern university at all professorial ranks. To conduct research and teach both graduate and undergraduate classes. Research interests of considerable importance. Send resume of education and experience to Box 2005.

CHIEF MICROWAVE ENGINEER

If you can assume the electrical design and test functions responsibilities for an outstanding company devoted exclusively to the manufacture of microwave components, (such as mixer-duplexers and antenna assemblies), this is the opportunity

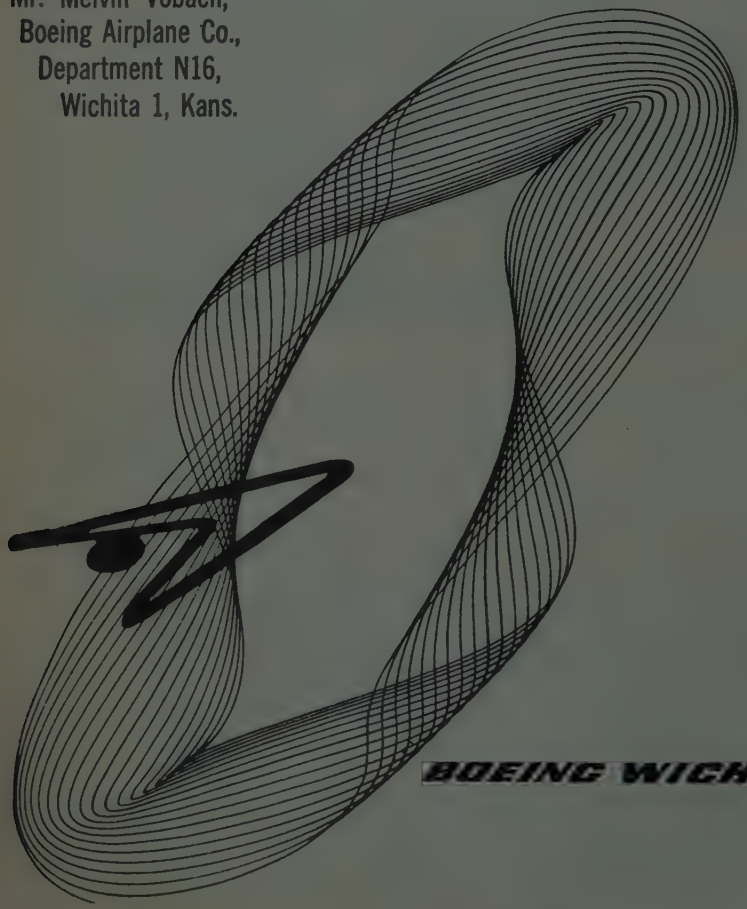
(Continued on page 160A)

AC Seeks and Solves the Significant—Because of GM's large contribution in the international race for technological superiority, AC accepts a challenge. AC Research is on a scientific quest for solutions to significant problems . . . for accomplishments even more advanced than AChiever inertial guidance for Titan. / We call this creative challenge . . . AC QUESTMANSHIP. It's an exciting quest for new ideas, components and systems . . . to advance AC's many projects in guidance, navigation, control and detection. / Right now Dr. Joseph F. Shea, AC's Director of Advanced Systems Research and Development, is drawing a group of competent men around him to build "the greatest R & D organization in the industry." And Dr. Shea adds strong support to the fact that AC offers "an excellent working atmosphere for a scientist or engineer who wishes to produce and progress." / You may qualify for our specially selected staff... if you have a B.S., M.S. or Ph.D. in the electronics, electrical or mechanical fields, plus related experience. If you are a "seeker and solver," write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

GUIDANCE / NAVIGATION / CONTROL / DETECTION / AC SPARK PLUG *The Electronics Division of General Motors*

patterns for tomorrow

for holders of advanced degrees now exist in Boeing Wichita's tremendously expanded long-range research and development program for **PHYSICISTS** or **ELECTRICAL RESEARCH ENGINEERS** to conduct acoustics and noise control research supporting advanced designs; to analyze survival properties of advanced vehicles in present and future environments; and evaluate the potential of vehicle defense proposals... **ANTENNA DESIGN ENGINEERS** to conduct research and development leading to miniaturization of antennas by use of loading dielectrics and/or ferrites... **CONFIGURATION DESIGNERS** to create military and civilian vehicle designs based on general missions parameters... **DYNAMIC LOADS ENGINEERS** to conduct research in existing and future air/space loads... **OPERATIONS AND WEAPONS SYSTEM ANALYSTS** to estimate operational utilities of various devices under study by Advanced Design and recommended optimum design parameters, using advanced (IBM-709) computer aids. Qualified engineers should communicate their interest in any of these top positions to Employment Manager, Mr. Melvin Vobach, Boeing Airplane Co., Department N16, Wichita 1, Kans.



BOEING WICHITA

Positions Open

(Continued from page 158A)

you have been searching for. Your ability will be the only factor in establishing the scope of your authority; your income will be commensurate. We offer liberal benefits, a substantial future and professional freedom and growth. Send complete resume in confidence to Personnel Dept., Budd-Stanley Co., Inc., 43-01 22nd St., Long Island City 1, N.Y.

ELECTRICAL ENGINEER

Evaluate instrument systems, establish calibration and operation procedures. Procurement, acceptance testing and shakedown of new instruments required in wind tunnel testing of models and propulsion systems of rockets and missiles. Establish preventive maintenance procedures, monitor data quality and improve instrumentation. Send resume and salary requirements to Technical Employment, ARO, Inc., Tullahoma, Tenn.

TEACHING POSITION

Excellent teaching opportunity will be available beginning Feb.-Sept. 1960. Advanced degree required. Attractive full year contract available. Salary range for 9 months is $5,000 to $7,000. Location is in the midwest at a medium-size private university. Complete resume to Box 2006.

INSTRUMENT OR ELECTRONIC ENGINEERS

Electronic or electrical engineer or physicist with instrumentation experience to do research and development work on the design, construction and evaluation of instrumentation for sampling and analysis of atmospheric air pollutants. Responsibilities for projects from design to prototype models. Salaries $5,500 to $8,200. Another, salary $10,130, in design and development of radiation measuring devices to direct program involving identification and measurement of radionuclides in environmental samples. Good prospects for growth and advancement. Federal Civil Service benefits and requirements. Apply U.S. Public Health Services, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio.

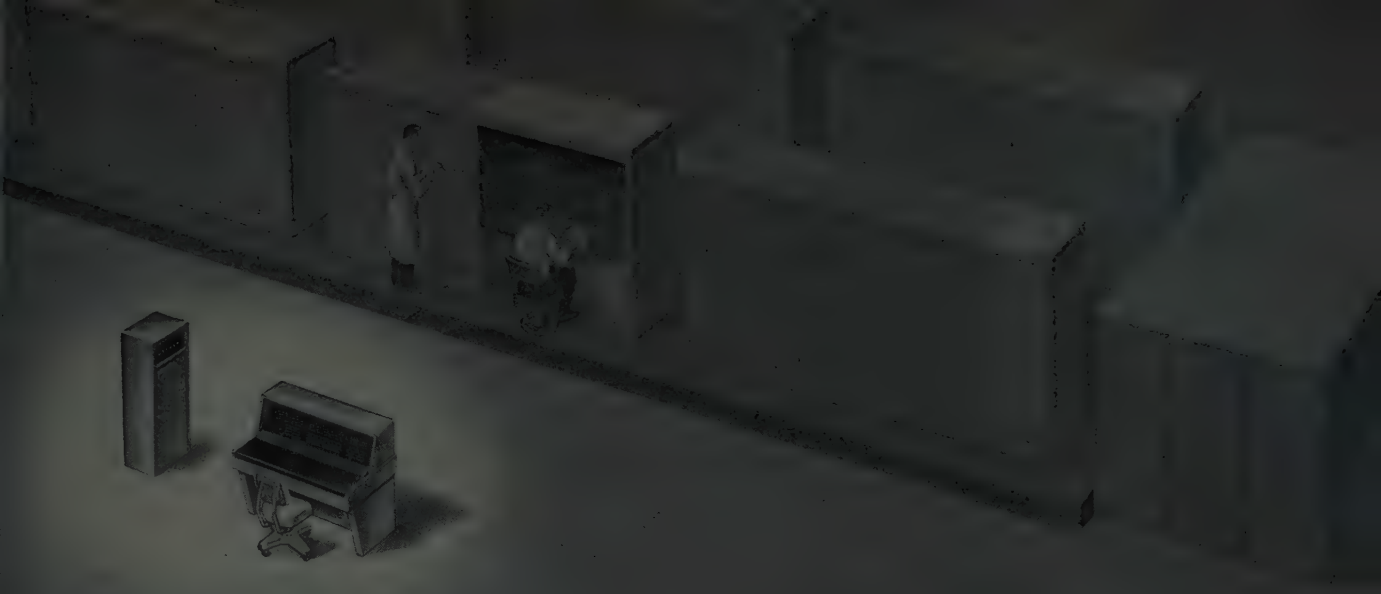
ENGINEERS

The Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn. has openings for graduate engineers in the areas of Propulsion Systems Performance Analysis, Heat Transfer Research, Ultra High Temperature Materials, Dynamics, Vibrations, Structures Research, Experimental Testing, Technical Report Writing and Propulsion System Control Engineering. Many of these openings are in our advanced Development Groups where we are presently conducting studies in solid and liquid propellants, ion propulsion, arc jet, plasma jet, and other advanced forms of propulsion. Openings are available at both the Conn. and Florida Facilities. For more information, contact Mr. Henry M. Heldmann, Employment Office.

PROFESSORS

Rank of Assistant Professor or Associate Professor, depending on qualifications. Salary $5,500 to $8,500 for session, 10 months nominal, 9 months actual. Start February or September 1960. Duties will include offering graduate courses and helping to develop research facilities. Opportunities for curriculum experimentation. Various sources of additional income available. Substantial allowance for relocation. Exceptionally good retirement plan. Fully accredited Electrical Engineering Dept. in medium sized university (700 undergraduate stu-

(Continued on page 164A)



Comparison between advanced Navy computer (foreground) and Univac Scientific (background) portrays dramatic reduction in size of large-capacity data processing equipment achieved by Remington Rand Univac.

The case of the shrinking computer

Central computer of the advanced Navy system shown at top of page illustrates compact size and ease of maintenance provided by building block construction. Containing 4,100 packages, the cabinet occupies only 37 cubic feet of space. Roll-out drawers permit easy and rapid access to component packages.

Remington Rand Univac compresses large-capacity performance into small package

In an advanced computer developed for the U.S. Navy, Remington Rand Univac dramatically reduced the size of large-scale data processing equipment. With a 32,786-word memory, the capacity of this miniaturized computer almost equals that of earlier vacuum tube systems of 10 times its size.

This compact, completely transistorized system has a cycle time of eight micro-seconds, and is linked with seven input-output registers, each of which may operate simultaneously and independently of computer programs.

Remington Rand Univac has openings on projects associated with advanced equipment such as the computer described above. These positions offer you the opportunity to advance your career development while at the same time participating in rapid advances in the state of the art.

If you are thinking of changing positions, or would consider a change, be sure to investigate the openings described below.

Opportunities for Electronic Engineers, Physicists and Mathematicians

COMPUTER APPLICATIONS ANALYSTS—Engineering, Mathematics, or Physics degree with experience in the use of large scale digital computers in real-time control systems, with emphasis on timing and control studies, data handling methods, and compiler development.

MILITARY SYSTEMS ANALYSTS—Engineering, Mathematics, or Physics degree with experience in weapons and missile guidance systems involving digital control, digital conversion, radar and communications information processing and display and output equipment.

BUSINESS SYSTEMS ANALYSTS—College degree with experience in business applications and programmings of digital data processing equipment as applied to production control, and maintenance logistics.

TRANSISTOR CIRCUIT DESIGNERS—Electrical Engineering degree with experience in transistorized pulse circuitry.

ENGINEER WRITERS—Engineering or Science degree with experience in the preparation of maintenance and operational manuals for electronic equipment.

QUALITY CONTROL ENGINEERS—Electrical Engineering degree with experience in reliability, statistical methods, and test procedures for electronic equipment.

CONTRACT REPRESENTATIVES—Engineering or Science degree with experience in government electronic R & D contracts.

SERVO-ENGINEERS—Electrical Engineering degree with experience in servo-amplifiers, servo-mechanisms and airborne electronics.

COMMUNICATIONS ENGINEERS—Electrical Engineering degree with experience in HF transmission, network theory and antenna design.

Send resume of education and experience to R. K. PATTERSON—Dept. D-1

Remington Rand Univac

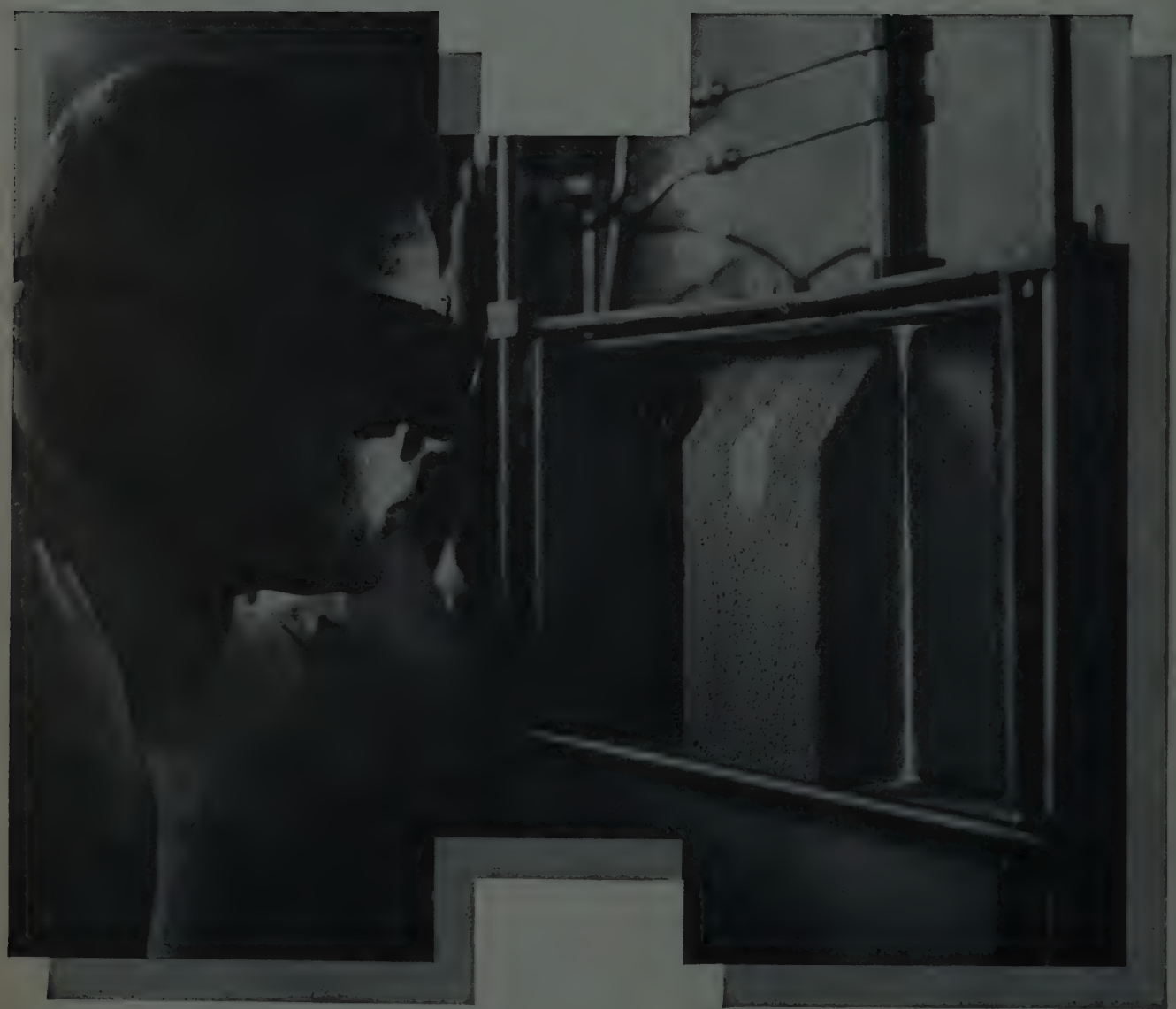
DIVISION OF SPERRY RAND CORPORATION
2750 West Seventh Street, St. Paul 16, Minnesota

All inquiries regarding openings at our other laboratories should be addressed to:

F. E. NAGLE—Dept. D-1
REMINGTON RAND UNIVAC
1900 West Allegheny, Philadelphia 29, Penn.

R. F. MARTIN—Dept. D-1
REMINGTON RAND UNIVAC
Wilson Avenue, South Norwalk, Conn.

alchemy in the 20th



century

In medieval times, alchemists spent lifetimes trying to transform the commonplace into the precious without success. Today, in the Hughes Research Laboratories, scientists and engineers using advanced methods and equipment, are synthesizing many new and precious materials to be used in solid state research.

The photograph, for example, shows a Hughes Research Laboratories scientist observing the growth of an yttrium aluminum garnet crystal using the flame fusion method. This work, as well as other crystal growth techniques, is part of a major Hughes materials research and supply program for the synthesis of ruby, sapphire, spinel, ferrite, garnet and related oxide single crystals. These materials provide atomic circuit elements which are the key to quantum electronics.

As solid state research at the Hughes Research Laboratories continues to expand and intensify, a supply of new and tailor-made materials in the form of high-quality single crystals is essential. Effective utilization and improvement of existing and new crystal growth methods requires extensive knowledge of their range of applicability, crystal growth mechanisms and the relationships between growth parameters and perfection of the resulting materials.

Feedback *in the form of performance data and suggestions for modifications to advanced Hughes Systems is provided by Hughes Field Engineers.*

Development *of new and highly reliable direct display storage and microwave tubes is being carried on at the Electron Tube Division, Hughes Products.*

Materials research is contributing significantly to existing ferrimagnetic, paramagnetic and absorption spectroscopic studies...and is opening new areas of investigation by providing materials not previously available as large single crystals.

Other Hughes activities cover practically every part of the electronics spectrum...providing stimulating outlets for creatively-oriented engineers. These include: Space Vehicles, Nuclear Electronics, Ballistic Missiles, Advanced Data Handling and Display Systems, Infrared Devices, Three-Dimensional Radar...and many others.

The variety and advanced nature of Hughes projects provides an ideal environment for the scientist or engineer who wishes to increase his professional stature.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Electroluminescence	Field Engineering
Infra-red	Equipment Engineering
Plasma Physics	Commercial Sales
Digital Computers	Microwave & Storage Tubes
Systems Design & Analysis	Communications Systems
Circuit Design & Evaluation	Micro Electronics

Write in confidence to Mr. D. E. Eikner
Hughes General Offices, Bldg. 6-E12, Culver City, Calif.

The West's leader in advanced ELECTRONICS

HUGHES

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HUGHES AIRCRAFT COMPANY

Culver City, El Segundo, Fullerton, Newport Beach, Malibu and Los Angeles, California; Tucson, Arizona

CAREER OPPORTUNITIES

With a company making premium grade electronic equipment for aircraft for over 30 years. Located in the beautiful lake region of Northern New Jersey, less than 35 miles from New York City.

Navigation Systems

Communication Systems

Servos

Transistors

Transmitters

Receivers

Antennas

- TRANSISTOR CIRCUIT ENGINEER
- TACAN ENGINEERS
- RECEIVER ENGINEERS
- TRANSMITTER ENGINEERS (VHF & UHF FREQUENCIES)
- NAVIGATION EQUIPMENT ENGINEERS
- ANTENNA DESIGN ENGINEER
- TEST LAB. ENGINEERS

Enjoy the pleasure of working in a new laboratory in a company whose products are known as the highest quality in the industry.

Write or call collect: Personnel Manager

AIRCRAFT RADIO CORPORATION

Boonton, N.J. DE 4-1800—Ext. 238

Positions Open

(Continued from page 160A)

dents in engineering) located in a very pleasant uncrowded city of 350,000. Address resume to Dean Otto Zmeskal, College of Engineering, University of Toledo, Toledo 6, Ohio.

INSTRUCTOR OR ASSISTANT PROFESSORS

Retirement of a staff member creates a vacancy in Electrical Technology Dept. for February 1960. Teaching area is mainly in electronics at the technician level. Minimum requirements are BEE. or BS. in E.E. and 2 years of industrial experience. Starting salary $5,000 to $7,000. Opportunity for an additional $2,000 through evening and summer teaching. Excellent pension system and other fringe benefits. Write to Prof. J. De France, Dept. of Elec. Tech., New York City Community College, 300 Pearl St., Brooklyn 1, New York.

SCIENCE AND ENGINEERING

Opportunities at Robert College, Istanbul, Turkey for qualified men in engineering, mathematics, physics and chemistry interested in combining teaching and the development of limited research and consulting activities with the opportunity to live and travel in a vital part of the world: Strengthening staff, modernizing undergraduate engineering curricula, beginning graduate programs in engineering, developing undergraduate and later graduate programs in sciences, constructing new science and engineering building to prepare engineers for the industrial and techno-

(Continued on page 168A)

The TECHNICAL MATERIEL CORPORATION

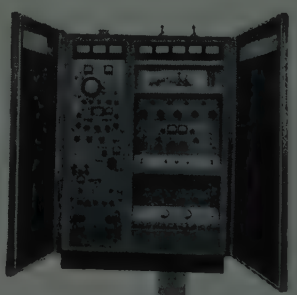
NEEDS

VOX Bulletin 134A

SENIOR ENGINEERS
PROJECT ENGINEERS

TO WORK ON

RECEIVERS
TRANSMITTERS
TERMINAL EQUIPMENT
IN THE LF/HF SPECTRUM
SSB-DSB-ISB-AM-FM-CW-FSK



GPT-10K Bulletin 207B

GPR-90 Bulletin 179

WRITE FOR CATALOG R-SF

Qualified Personnel are invited to send RESUME TO

Mr. Ernest Matson, Sr.
DEPT. R-119
700 FENIMORE ROAD
MAMARONECK, N.Y.

ELECTRONIC DESIGN ENGINEERS

R.F. CIRCUIT DESIGNER—VHF to S Band, to design RF circuitry for receivers or multi-stage transmitters for secure command system.

RECEIVER DESIGNERS—to design and develop advanced transistorized receivers for secure command system.

AMPLIFIER ENGINEERS—for circuit development on transistorized amplifiers used in inertial systems.

TRANSISTOR SPECIALISTS—for design and development of transistorized circuitry for digital systems and/or use in transistorized receivers.
2-3 years applicable experience in transistorized electronics development.

To arrange interview call collect, Niagara Falls BUtler 5-7851, or send resume to:

Supervisor Engineering Employment

BELL AIRCRAFT CORP.

BUFFALO 5, NEW YORK

RESEARCH ⇌ INSTRUMENTATION

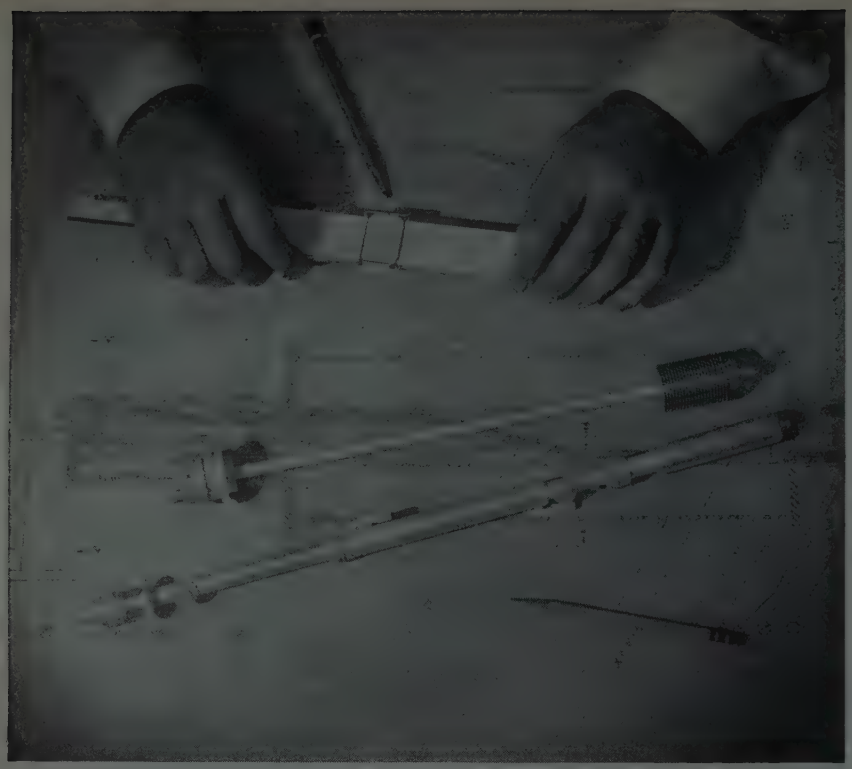
Recognizing that research and instrumentation are always interdependent, Argonne maintains an intensive instrument program to support its research efforts. Both the requirements of the unique problems and the diversified techniques used have resulted in an instrument program of unusual breadth and interest. Research progress is, in turn, immeasurably enhanced by the devices—both electronic and otherwise—arising from this program and by the availability of the instrument experts involved.

Staff positions are now available in both instrumentation and research fields for experienced as well as recently graduated B.S., M.S., and Ph.D. scientists and engineers.

We would like to hear from you concerning your interests.

Argonne
NATIONAL LABORATORY
Operated by the University of Chicago under a contract with the United States Atomic Energy Commission

Please write to:
DR. LOUIS A. TURNER, DEPUTY DIRECTOR
P.O. BOX 299-U6 · LEMONT, ILLINOIS



Senior Level Positions in Fast Growing Microwave Research and Engineering Programs

Project Level Responsibility

A 100 watt CW, C-Band ceramic traveling wave tube has recently been developed by Eimac. It is just one of the steps Eimac is taking in the field of electron devices to take advantage of microwave frequencies. In TWT's, reflex and amplifier klystrons, Eimac is, and will continue to be, the leader in advancing the state of the art. Career opportunities are now available for outstanding engineers with BS, MS, and PhD degrees with a company specializing in electron tubes.

1. Research Engineers and Scientists to conduct theoretical and experimental research in microwave measurements, microwave tube problems, plasma physics and circuit design.
2. Microwave Engineers to test and evaluate tube performance and design of VHF and UHF circuits with respect to klystrons, negative grid tubes and traveling wave tubes.
3. Project Engineers to assume responsibility for existing and newly-approved projects in high power klystrons... including design and testing of electronic guns, cavities and related tube components.

Salaries offered are excellent and, naturally, Eitel-McCullough will pay relocation expenses to the company's facilities in Salt Lake City, Utah and San Carlos, California. All replies will be honored with the strictest confidence. Please write: C. F. Giesler, Dept. P, Eitel-McCullough, Inc., San Carlos, California.

Eimac

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

Electronic and Electromechanical

SYSTEMS ENGINEERS

Openings are waiting for you at Autonetics

in

Systems Research and Development

on

Integrated Systems involving the following equipments:

Radars

Inertial Guidance

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Flight Control Equipment

Opportunities have never been better in the history of Autonetics for the engineer with sound technical competence in the above fields.

Advanced degrees preferred, with four to ten years' broad experience in the above or related fields.

Send your resume to:
Mr. B. D. Benning
Manager, Employment Services
Dept. G-123
9150 East Imperial Highway
Downey, California

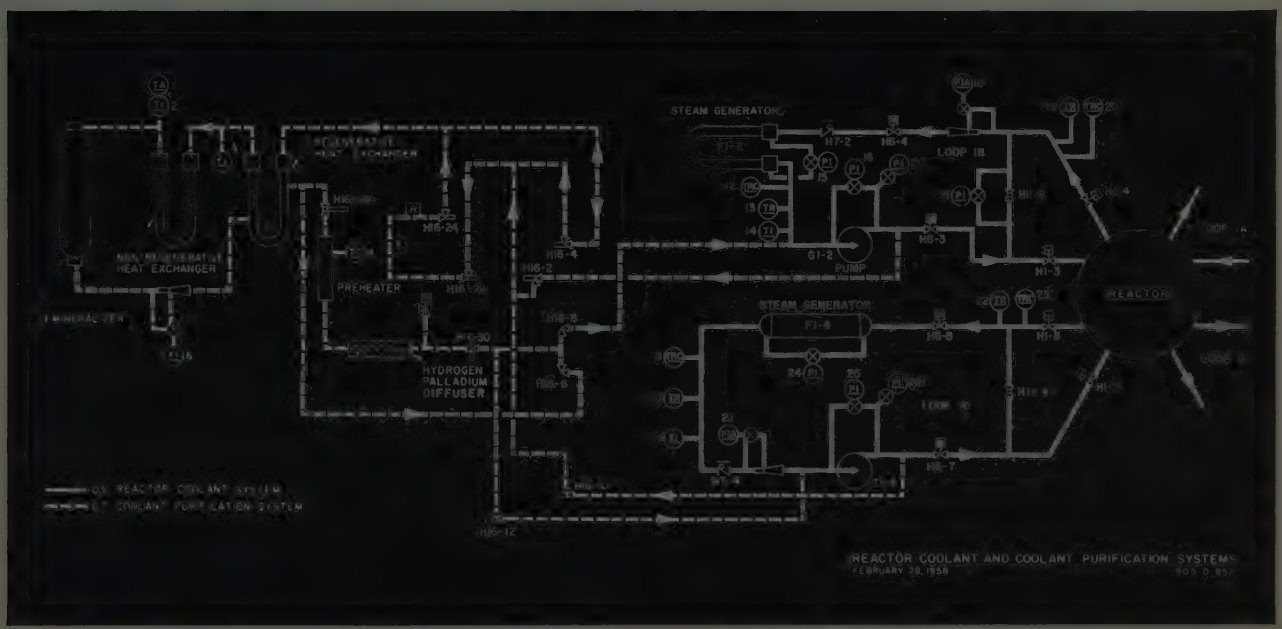
Autonetics
A Division of North American Aviation, Inc.

PHYSICISTS
MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS
CHEMICAL ENGINEERS

To physicists; mechanical, electrical, or chemical engineers who want to explore the professional development aspects of the nuclear power field, the Bettis Atomic Power Laboratory offers to competent engineers problem areas in the design and development of nuclear power plants that require detailed mathematical models, and use of differential equations as they apply to thermodynamics, fluid system analysis and system steady state and transient operation.

NUCLEAR SYSTEM DESIGN

If you are a physicist, mechanical, electrical, or chemical engineer and are interested in pursuing a career in nuclear system design and development and you are a U. S. Citizen, write to: Mr. M. J. Downey, Bettis Atomic Power Laboratory, P. O. Box 1526, Dept. B-12, Pittsburgh 30, Pa.



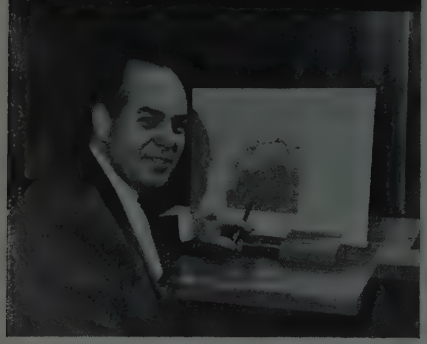
BETTIS ATOMIC POWER LABORATORY

Westinghouse

BETTER YOUR FUTURE AT BETTIS

A Personal Invitation to

ENGINEERS



from BOB TEASDALE

Manager—ELECTRONICS DIVISION

"The great Southwest is a wonderful place to live, and Temco Electronics, located in suburban Dallas, is a good place to work. Here, like other Temco employees, you and your family will enjoy a dry, healthful climate..beautiful, moderate priced homes..outstanding medical facilities..excellent school system..fine universities..all sports and recreation..churches of all faiths.. and *no* state income tax or general sales tax. Every benefit, for you professionally and in good living for you and your family, is here. Below are some of the areas in which jobs are open now."

RADAR CIRCUIT DESIGN

Microwave • Modulator • IF Amplifier
Indicator • Video Amplifier • M.T.I.

SYSTEM DESIGN

Airborne Radar • Fire Control
Ground Based Search Radar
Auxiliary Equipment • ECCM

SALES ENGINEER

To contact military agencies and commercial organizations for determination of electronic products and systems requirements.

To arrange for convenient interviews, write in confidence to:

BILL G. HICKEY
Supervisor Technical Employment
Room 121R, P. O. Box 6191

TEMCO
ELECTRONICS

A Division of TEMCO AIRCRAFT CORP.
Dallas 22, Texas

Positions Open

(Continued from page 164A)

logical development of Turkey and the Middle East. Address inquiries to Dean Howard P. Hall of the College of Engineering, Robert College, Bebek P.O. 8, Istanbul, Turkey, with copy to Near East College Assoc., 40 Worth St., Rm. 521, New York 13, N.Y.

DEVELOPMENT ENGINEER

Development Engineer to head a small development group in the field of small electronic components. Degree, or its equivalent, and experience in this field required. Write Philadelphia Plant Employment, International Resistance Co., 401 North Broad St., Philadelphia 8, Pa.

STAFF IN ELECTRICAL ENGINEERING

Attractive positions combining teaching (graduate and undergraduate) and research are available. Appointment at any level from Assist. Professor up, depending on qualifications. A person with interests in electrical energy conversion and modern electrical machines is especially sought, but openings in other fields are available. Applicants must have Ph.D. or equivalent evidence of research potential. Write Chairman, Div. of Engineering, Brown University, Providence 12, R. I.

TECHNICAL SALES ENGINEER

Knowledge of Government operations and experience in microwave tube field desired. Retired service personnel would be considered. Good position in growing company. Please call or write American Radio Company, Inc., 445 Park Ave., New York 22, N.Y. Pl-3-5046.

(Continued on page 170A)

INFRARED DEVELOPMENT ENGINEER

Experienced man wanted with background in infrared instrumentation. Unusual infrared applications in research and commercial equipment. Unique opportunity for a capable man seeking new horizons.

Location Queens, N.Y.C. Salary and responsibilities will be tailored to the individual.

THE WARNER & SWASEY CO., CONTROL INSTRUMENT DIVISION
34 West 33 Street **New York 1, N.Y.**

PROJECT ENGINEERS

For design and development of ground support and electronic test equipment. Experience in ground support equipment for instrumentation and navigational systems desirable.

SALES ENGINEERS

Excellent opportunities in a newly established department for *commercial sales* with world-wide scope of activities, as well as in the *Military Marketing Group*.

PRODUCT ENGINEERS, ME & EE

For design of production test equipment for electromechanical systems.

Kollsman is seeking a limited group of exceptional men to participate in its continuing growth in the field of automatic navigation and flight instrumentation. These openings offer unusual opportunity with an organization intimate enough to allow individual recognition, yet large enough to assure stability.

Please send resumes to T. A. DeLuca.

kollsman INSTRUMENT CORPORATION

80-08 45th AVENUE, ELMHURST, NEW YORK • SUBSIDIARY OF *Standard* COIL PRODUCTS CO. INC.

Vitro Laboratories' Florida Operation, Vitro Weapons Services, is rapidly expanding its professional staff to meet new contractual and technical requirements.

For the last nine years, Vitro has assisted the Air Research and Development Command in planning, developing, installing and operating the test ranges and facilities of the Air Proving Ground Center, Eglin Air Force Base, Florida. Current projects include test of the *Bomarc, Quail, Hound Dog* and *Genie* missile systems, as well as investigations in the fields of frequency diversity, electronic countermeasures, vertical launching, high altitude research and drone development.

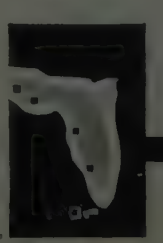
Now we are accelerating our activities to operate the nation's newest missile range, the Eglin Gulf Test Range, which extends some 450 miles from Eglin to Key West, Florida. This new responsibility in part explains our dynamic growth, but more particularly, it creates outstanding supervisory and staff openings for:

Electronic Engineers—with degree(s) in E.E., plus experience in Automatic Tracking Radar, Electronic Instrumentation, Phase Comparison Space Positioning Systems, Data Recording and Conversion, Telemetry or Missile Range Instrumentation. These are senior level positions, particularly challenging to the man with field engineering and design experience in tracking type radar systems.

Radar Technicians—with training and experience in MSQ-1, MSQ-1A, FPS-16, Nike, M-33, MPS-9, SCR-584, CPS-6, FPS-3 and FPS-20 equipments.

Electronic Technicians—with a solid background in electronics and several years experience in Telemetry, Data Converters, Oscillograph Recorders or Range Electronic Instrumentation.

To focus your future on a career with Vitro in Florida, please submit a brief resume of your experience in confidence to Mr. D. D. Cox, *Director of Personnel*, Vitro Weapons Services, 119 East Main Street, Fort Walton Beach, Florida, Dept. P-1. All replies will be answered immediately, and interviews will be arranged.



Vitro LABORATORIES
Division of Vitro Corporation of America

VITRO WEAPONS SERVICES
EGLIN AIR FORCE BASE, FLORIDA

Other laboratories at West Orange, N. J., and Silver Spring, Md.

ELECTRONIC ENGINEERS

The expanding activities of the Armour Research Foundation, an independent research organization, requires the services of several additional experienced engineers to work on its many diversified research programs. As a member of our staff you will enjoy the friendly atmosphere and cooperation which exists plus the exceptional opportunity for creative research coupled with excellent facilities, working conditions and stimulating staff associations. In many cases you are able to work on ideas of your own choosing through our internally sponsored research activities.

Applicants should possess several years of experience in one or more of the following areas:

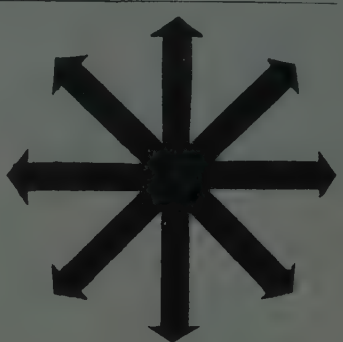
Communication and Radar Systems Analysis
Microwave Field Theory
Radio-Radar Interference

Salaries are offered to suit your individual experience and educational background. Benefits include liberal insurance and retirement programs, a vacation policy which provides up to four weeks vacation per year, tuition free graduate study and a generous relocation allowance.

If you are interested in this challenging opportunity to advance professionally, please send a resume of your qualifications to:

A. J. Panerai
ARMOUR RESEARCH FOUNDATION
of Illinois Institute of Technology
10 West 35th St. Chicago 16, Ill.

growth at granger associates



creates extraordinary opportunities now **at all levels** as techniques specialists and project managers in the development and manufacture of advanced r-f systems...including traveling wave tube applications, **transistor circuits,** transmitter and receiver techniques, microwave components, distributed amplifiers, and **antennas** for airborne and ground-based systems. Vital projects...a blue ribbon staff...and an expanding employee-owned company...add up to **unlimited potential.** For details inquire direct to Dr. J. V. N. Granger at **granger associates**
974 commercial street / palo alto, california

Positions Open

(Continued from page 168A)

PRODUCTION FOREMAN

Production Foreman—Electronic Transformer: 5 years (+) experience in coil winding business. Familiar with general machine shop equipment and vacuum potting techniques. New company. Excellent opportunity. Sunny San Diego. Apply Atlas Transformer Co., 1839 Moore St., San Diego 1, Calif.

ASSOCIATE PROFESSOR

Electrical Engineering faculty being expanded in rapidly growing department, graduating first class in 1960. Current positions available to rank of Associate Professor and to 9 months salary of $6,000, depending upon education and experience. Background emphasis preferably upon electronics and advanced circuit theory. Opportunity for research and other industrial programs in the area. Send full background to Chairman, Electrical Engineering, University of Bridgeport, Conn.

Positions Wanted

By Armed Forces Veterans

In order to give a reasonably equal opportunity to all applicants and to avoid overcrowding of the corresponding column, the following rules have been adopted.

The IRE publishes free of charge notices of positions wanted by IRE members who are now in the Service or have received an honorable discharge. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion and the maximum number of insertions is three per year. The IRE necessarily reserves the right to decline any announcement without assignment of reason.

Address replies to box number indicated, c/o IRE, 1 East 79th St., New York 21, N.Y.

DIGITAL SYSTEMS ENGINEER

BEE.; Tau Beta Pi, Eta Kappa Nu; graduate work in digital techniques. 6 years broad experience, logical design, systems integration, transistorized circuit design, systems evaluation. Married, 2 children. Desires position in Japan or other opportunity of unusual interest. Box 2031 W.

ELECTRICAL ENGINEER

Age 23. BEE. Georgia Tech. September 1957. 1/Lt. U.S. Army Ordnance Corps. 1½ years as project coordinator at White Sands. Desires position in missile instrumentation or allied field with management opportunities. Location southeast or southwest. Box 2032 W.

ELECTRONIC TECHNICIAN

Signals Officer 15½ years service in HF communication work. Age 37. Associate Brit. IRE. Associate Member IRE (USA). Graduate H.R.T.

(Continued on page 174A)

T. R. Selig, B.S. Physics 1954, St. Norbert College. Joined G-E Physics Training Program June 1954. Went from Advanced Technical Course to 4 rotating assignments. U. S. Navy 2 years. Returned to G-E Semiconductors in Advance Process Group. Has worked on power transistors, multi-layer switches and the new tunnel diode (100 times faster than a transistor). Studying for M.S. in Physics. Married; 2 children.

Tom Selig takes time off from the tunnel diode . . .

to tell you about General Electric's Semiconductor Products Dept.

"In the General Electric Company, each department must stand on its own two feet. It's like working for a small company, but with the depth of talent and technical backup you find only in a large organization.

"G-E Semiconductors has an expert in almost any subject you may be working on. They are found within your own group, in the Advanced Semiconductor Laboratory, and at the Research and Engineering Laboratories in Schenectady. Each is a recognized authority in his field and all are available for consultation at any time. You have only to pick up the phone.

"My present assignment, the tunnel diode, calls for work with electrical, chemical and physical phenomena. This is typical of semiconductor development and leads to a broad background in several areas, strengthened by the educational opportunities at G.E. There are about 30 engineering courses taught here at General Electric, besides tuition refund for advanced study at Syracuse University."

●

Unusual opportunities now open for chemical, electrical, mechanical and metallurgical engineers, physicists and physical chemists (B.S. through Ph.D.) at all levels of experience. U. S. citizenship not required. Semiconductor experience desirable but not essential. Write in strict confidence to Mr. M. D. Chilcote, Division J4.

GENERAL ELECTRIC

Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

Put Yourself in this "Growth" Picture

grow faster with a growing company . . .

utilize advanced facilities available

for research, development

and manufacturing projects of the highest technical nature

. . . where your work and talents are recognized

as extremely vital . . . enjoy year-round living

and recreation in the pleasant Southwestern climate

To date, almost 14,000 people at Texas Instruments are in this "Growth" picture. In addition, they are enjoying many other benefits from TI's enlightened personnel policy — company-sponsored profit sharing plan*, periodic advancement and salary reviews, educational assistance, insurance, and retirement programs.

TI offers a stimulating challenge in research, development and manufacture in geosciences, military and industrial instruments and systems, semiconductors and other electronic components. To keep its position as a leader in these fields, and to stay ahead of the ever-increasing demands of Space Age technology, more new permanent positions have been created for qualified Engineers.

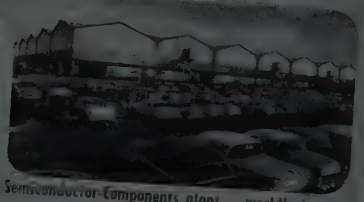
Come grow with us . . . work and live in an environment of professional, social and recreational freedom. Write to your area of interest on the right.

*Which, in 1958, was 15% of base salary!

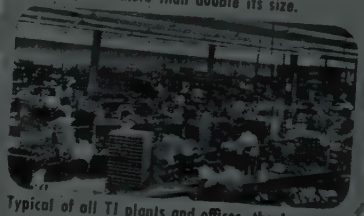
you'll grow faster with a growing company!

TEXAS INSTRUMENTS
INCORPORATED
DALLAS 9, TEXAS

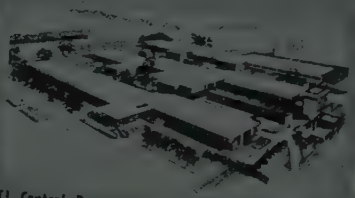
Over the past decade, TI personnel increased over 15-fold from 800 to almost 14,000. Will be 15,000 by end of 1959.



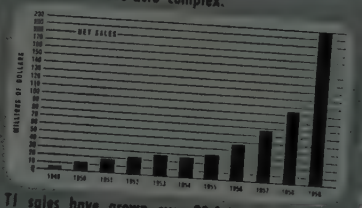
Semiconductor-Components plant . . . world's largest semiconductor manufacturing facility. Construction underway will more than double its size.



Typical of all TI plants and offices, the Apparatus division assembly area is well-lighted and air-conditioned.

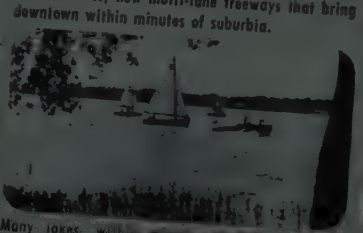


TI Central Research Laboratory's new building, located adjacent to the Semiconductor-Components plant at the 300-acre complex.



TI sales have grown over 20-fold over the past ten years . . . from under $5,000,000 to $200,000,000 for 1959.

Typical of Dallas and Houston modern buildings and facilities, new multi-lane freeways that bring downtown within minutes of suburbia.



Many lakes, within minutes of Dallas, provide excellent recreation. Houston is "next door" to Galveston, nationally known seaside resort.

specific career opportunities now open at Texas Instruments

SEMICONDUCTOR-COMPONENTS DIVISION

DEVICE DEVELOPMENT—Develop new semiconductor devices; conduct experimental and theoretical studies on the effects of nuclear radiation on semiconductor materials and devices; evaluate experiments in the analysis of gases and electro-chemistry; conduct physical measurements on semiconductor surfaces; determine the effects of chemical reaction on semiconductor surfaces; studies in device stability, reliability and characterization; materials research and development including crystal growth and crystallography.
CIRCUIT DEVELOPMENT—Transistor circuit design and application; design automatic and semi-automatic test equipment.
MECHANIZATION—Design and develop high speed automatic machinery.
Please write to C. A. Besio, Dept. 1004, P. O. Box 312, Dallas, Texas

APPARATUS DIVISION

MANUFACTURING ENGINEER—To perform the planning and coordination of the manufacture of electro-mechanical/electronic systems and components on an assigned project basis; to determine action to be taken; follow-up and report successful operation of the course of action selected. BS in EE, ME or IE, with minimum 3 years experience in manufacturing processes, tooling, scheduling, and costs.
QUALITY CONTROL ENGINEER—To establish and maintain standards of quality and inspection methods for all raw materials, work in process and finished products. BS in EE, ME or IE with minimum 3 years experience in working to customer requirements, procedures, quality reports plus prevention and detection of defects in electro-mechanical apparatus.
SENIOR MICROWAVE ENGINEER—To perform applied research and development in the field of microwave and high-powered transmitter equipment including ASR transmitter and automatic performance monitoring. MS in Physics or EE with minimum 5 years experience in the field of microwave and high-powered transmitting equipment.
SENIOR ELECTRONIC ENGINEER—To conduct engineering analysis of techniques that will be incorporated into various product lines. Electronic design experience associated with the missile field involving circuit (transistor), computers, telemetry, and guidance systems design essential. MS in EE, ME or Physics with minimum 7 years experience in field of missile electronic design and systems planning and analysis.
CIRCUIT DESIGN ENGINEER—With strong instrumentation background with emphasis on circuit design. Experience in application of transistor circuits to instrumentation highly desirable although not essential. BS or MS in EE or Physics with minimum 5 years experience.
RESEARCH ANALYST—To perform industrial marketing research in the field of military and industrial electronics; requires analytical ability with imagination to foresee variables and recognize limitations and data; ability to present ideas clearly in verbal and written form. Must also be able to interpret and point out use and conclusion of statistical studies to division management. BS in ME, EE or MBA or MA in Economics.
SENIOR GUIDANCE ENGINEER—To design microwave antennas and circuit components; supervise engineering personnel in design and development of complete missile antenna and microwave systems; contribute original advancements in missile microwave and antenna concepts for proposals and system development. BS in EE or Physics with minimum of 5 years experience in stripline microwave design. Also thoroughly familiar with radiation and propagation theory.
MATHEMATICAL STATISTICIAN—To specialize in the study of noise applications; to perform systems analysis of sonar and radar product lines; to provide consulting service to other technical personnel. MS or PhD in Mathematics with minimum of 6 years experience in applied analysis of advanced mathematics.
MATHEMATICIAN—To specialize in transform calculus as applied to servo mechanisms and network analysis and continued fraction work; provide consulting services to other technical personnel. MS or PhD in Mathematics with minimum of 6 years experience in applied analysis of advanced mathematics.
Please write to John Pinkston, Professional Placement, Dept. 1004, 6000 Lemmon Avenue, Dallas 9, Texas

GEOSCIENCES AND INSTRUMENTATION DIVISION

MECHANICAL DESIGN ENGINEERS—BS or MS in ME to design small electro-mechanical mechanisms.
ELECTRICAL DESIGN ENGINEERS—BS in EE or Physics to design and construct supervisory control systems of electro-mechanical and electronic design; transistor test equipment, requiring heavy experience on electronic circuit design, preferably with transistors; digital computers with experience in detailed logical design.
MANUFACTURING ENGINEER—BS in ME or IE with experience in production, planning, production control, methods and tooling in the electronics industry.
SALES ENGINEER—BS in EE, Physics or ME with sales experience in electro-mechanical instruments.
Please write to Dave Turner, Dept. 1004, 3609 Buffalo Speedway, Houston, Texas

CENTRAL RESEARCH LABORATORY

HEAD—PHYSICS SECTION—4 to 5 years experience in semiconductor physics and proven ability to direct a variety of technical projects. Responsible for directing work on the measurement and understanding of electrical, thermal, magnetic, optical, and transport properties of semiconductors. Educational requirement is PhD in Physics.
HEAD—DEVICE SECTION—4 to 5 years experience in semiconductors plus experience in group leadership and proven ability to supervise a variety of technical projects. Will be responsible for directing work on design, fabrication and evaluation of new solid state devices. Educational requirement is MS or PhD in either Physics or EE.
SOLID STATE THEORIST—Responsible for the understanding and interpretation of the physical properties of semiconductors and other solid state materials. Educational requirements: PhD in Physics with concentration in quantum mechanics. Solid state experience desirable but not necessary.
DEVICE THEORIST—Responsible for the design of new solid state devices and interpretation of their characteristics in terms of physical and fabrication parameters. Educational requirement is PhD in Physics or EE, or MS with 2 to 3 years experience in solid state device theory.
SEMICONDUCTOR TECHNOLOGY—Responsible for the design and interpretation of experiments on the technology of semiconductors, including impurity diffusion and alloying. Educational requirement is PhD in Physical Chemistry or Metallurgy. Experience requirement: 3 to 4 years experience in semiconductor technology.
THEORETICAL PHYSICIST—2 to 3 years experience in electron or nuclear magnetic resonance with interest and background to perform theoretical analysis of EMR and NMR to develop possible new types of magnetometers or to make significant improvement in present types. Sufficient experimental background and interest to assist in translating theoretical results into experimental projects.
PHYSICISTS—Either MS or PhD with 1 year minimum experience in the fields of superconductivity and low temperature physics. Should be acquainted with conventional techniques of transferring and handling liquid helium and designing circuits and instrumentation for studies in this area.
Please write to A. E. Prescott, Dept. 1004, P. O. Box 1079, Dallas, Texas

An Invitation To Join ORO...Pioneer In Operations Research

Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

At ORO, a civilian and non-governmental organization, you will become one of a team assigned to vital military problems in the area of tactics, strategy, logistics, weapons systems analysis and communications.

No other Operations Research organization has the broad experience of ORO. Founded in 1948 by Dr. Ellis A. Johnson, pioneer of U. S. Opsearch, ORO's research findings have influenced decision-making on the highest military levels.

ORO's professional atmosphere encourages those with initiative and imagination to broaden their scientific capabilities. For example, staff members are taught to "program" their own material for the Univac computer so that they can use its services at any time they so desire.

ORO starting salaries are competitive with those of industry and other private research organizations. Promotions are based solely on merit. The "fringe" benefits offered are ahead of those given by many companies.

The cultural and historical features which attract visitors to Washington, D. C. are but a short drive from the pleasant Bethesda suburb in which ORO is located. Attractive homes and apartments are within walking distance and readily available in all price ranges. Schools are excellent.

For further information write:
Professional Appointments

OPERATIONS RESEARCH OFFICE
ORO The Johns Hopkins University
6935 ARLINGTON ROAD
BETHESDA 14, MARYLAND

By Armed Forces Veterans

(Continued from page 170A)

Institute, Los Angeles. Desires suitable position, willing to undergo preparatory training if necessary. Non-U.S. citizen, at present residing outside USA. Location—any part of the world, preferably U.S. or possessions. Box 2033 W.

EDITOR—PUBLICATIONS MANAGER

B.S. in physics; 10 years technical writing experience including 4 years as supervisor; 3 years teaching radio and television repair, laboratory and theory; holder of 1st class radiotelephone license; excellent mathematician; expert typist and stenographer. Desires position as editor of electronics periodical or as supervisor in publications section of manufacturer of electronic equipment. New York City area preferred. Box 2034 W.

TECHNICAL REPRESENTATIVE

Assistant to Technical Director in Europe desires position of broad responsibility in Europe. University training in eng. and administration; 10 years comm. and mil. elec. Member IRE; FCC 1st. Age 40. Married. Box 2035 W.

ELECTRONIC ENGINEER

Completing Ph.D. in E.E. this fall at large midwestern university. 6 years broad experience in ECM, communication, and control systems. Strong background in applied mathematics. Former Fulbright scholar. Desires long term position in continental Europe. Age 29, married, U.S. citizen, languages. Box 2039 W.

(Continued on page 178A)

INERTIAL PLATFORM ENGINEER

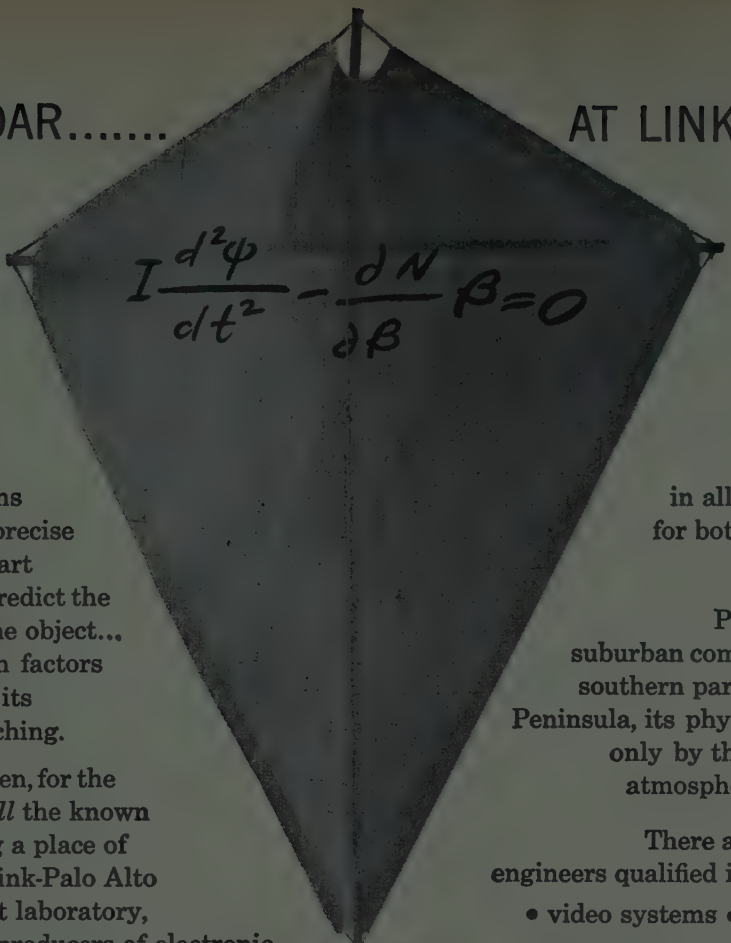
To be responsible for inertial navigator platform subsystems development. 2-3 years experience desired in inertial electronics and platform development.

To arrange interview call collect, Niagara Falls BUtler 5-7851, or send resume to:

Supervisor Engineering Employment

BELL AIRCRAFT CORP.
BUFFALO 5, NEW YORK

CAREERS SOAR..... AT LINK-PALO ALTO



An engineer soon learns that in order to make precise projections, he must start with precise facts. To predict the reactions of an airborne object... even a kite...all known factors must be considered in its construction and launching.

How important it is, then, for the engineer to consider *all* the known factors when choosing a place of employment. At the Link-Palo Alto electronic development laboratory, (pioneers and leading producers of electronic flight simulators) *all* the facts are favorable.

Link has three distinct and diverse development departments: *Industrial products development... Military electronics... Advanced computer development.*

This arrangement opens up a great diversity of assignments and excellent opportunity for advancement, as the lab is expanding rapidly in all areas of development for both our commercial and military customers.

Palo Alto is a charming, suburban community located on the southern part of the San Francisco Peninsula, its physical climate matched only by the benign professional atmosphere at the Laboratory.

There are many openings for engineers qualified in the following fields:

• video systems • electronic packaging
• IR techniques • engineering psychology
• advanced data processing systems
• advanced electro-mechanical design
• circuit analysis • computer design
• weapon system analysis

Move up! Write to
Mr. B. U. Rutman, Link Aviation, Inc.
P.O. Box 1318, Palo Alto, California

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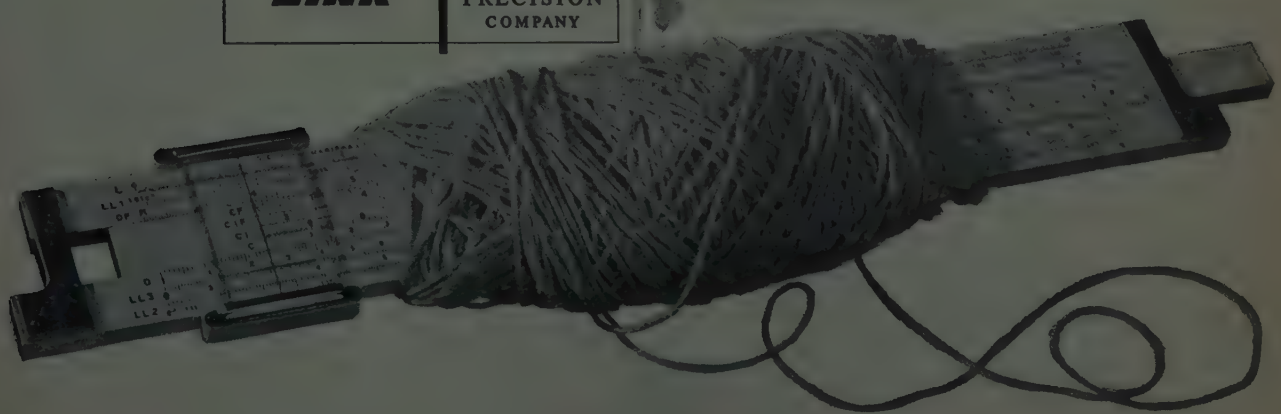


Lockheed Missiles and Space Division

invites your inquiry into these

UNUSUAL RESEARCH AND DEVELOPMENT

OPPORTUNITIES

Important career positions are available at Lockheed Missiles and Space Division at its new facilities on the beautiful San Francisco Peninsula – one of the choicest living areas in the nation. Headquarters for the Division are at Sunnyvale, California, with Research and Development Facilities located in the Stanford Industrial Park in nearby Palo Alto.

The Division is widely diversified—having complete capability in more than 40 areas of science and technology, from concept to operation. Areas of work include: metallurgy; sonics; reconnaissance; computer design and development; propulsion and exotic fuels; space physics; hydrodynamics; the flight sciences; space medicine; manned space vehicles; telemetry; electronics; applied mathematics; operations research and analysis; space communications; reentry; design; and test, both environmental and flight.

Equipment and facilities are completely modern and include one of the largest computer centers in the world.

The Division is systems manager for several major long-range projects and its research and development programs reach far into the future. It is a rewarding future with a company that has an outstanding record of leadership and progress.

Unusual opportunities exist for experienced engineers and scientists to contribute to the solution of new problems in the areas listed on the next page. If you are experienced in these areas, or have background in related fields, we invite your inquiry. Please write: Research and Development Staff, Dept. L-33, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship required.

Advanced degree preferred with background in one or more of the following areas: flight test analysis of reentry trajectories and/or systems evaluation; flight test analysis of trajectories and separation evaluation; theory of subsonic and hypersonic aerodynamics; underwater stability and control hydrodynamics; aerodynamic preliminary design studies; research in gas dynamics studies of thrust vector controls, stage separation, propulsion systems analysis, and rocket nozzle design; or wind tunnel studies and testing.

Advanced degree required with real time experience with analog computers. For the solution of problems in flight controls; guidance; aero and thermo dynamics; dynamic analysis and process controls.

Advanced degree in E.E. preferred with background of several years' experience in antenna design for space vehicles.

Ph.D. preferred, advanced degree required, with strong research background for development work in fuel cells; batteries; the direct conversion of electrochemical energy; electrode kinetics; catalysis; photochemistry; thin film; and solid state. Work concerns both military and commercial applications.

Advanced degree required, Ph.D. preferred with background in either physical-organic chemistry; inorganic chemistry; analytical chemistry; or electrochemistry for research and development work in such areas as: instrumental analytical techniques including infrared, ultraviolet and mass spectroscopy; gas solid reaction kinetics; microchemical analysis techniques; surface treatment of metals and surface reaction kinetics; molecular resistance of substances to various environments including formulation of elastomers; or reinforced plastics.

Advanced degree in E.E. or physics preferred but not required, with experience in infrared systems research and development, or electrical engineers with background in electronics information theory; servomechanisms; specialized circuitry, as in low-level voltage circuits, or physicists with background in optics or semi-conductors. For work in infrared physics research; advanced systems development; or physical measurements in infrared.

Degree in E.E. or communications with background in design of UHF, VHF and RF transmitters; telemetry systems and components; circuit design or logical design components.

Background of graduate work in E.E. or math., with interest in advanced areas of computer research in such efforts as: pattern recognition; automata studies; logical design and switching theory; information retrieval; and behavior patterns of artificial neurons patterned closely after those of the human brain.

Advanced degree in M.E. preferred with background of mechanisms and small structures desirable. For research in experimental design and the development of a variety of research test models.

Advanced degree in M.E. preferred with experience in the design of aero and thermodynamic missile scale models including previous work in wind tunnel model design and test. Shop liaison experience desirable.

Advanced degree preferred for basic and applied research in one or more of the following areas: metallurgical behavior and mechanisms concerning high temperature and advanced missile materials with interest in metal physics; deformation and fracture; phase equilibria; transformations; or diffusion. Also, to conduct basic and applied studies in refractory metals; dispersed phase systems; fiber metallurgy; ceramics and thermal protective materials systems. Also, for X-ray and electron diffraction research and studies in single crystals; point defects; parameter measurements; pole figure determinations.

Experience required in MASER amplifiers and variable reactance parametric devices, for experimental research in microwave.

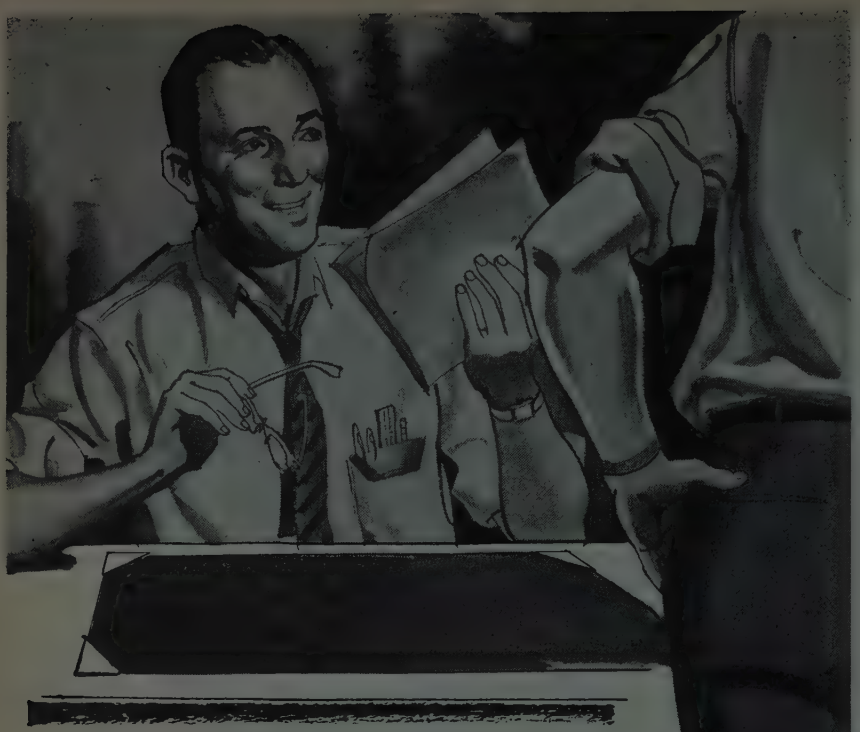
Degree in E.E. required and several years' experience in developmental testing of ordnance and pyrotechnic devices, preferably in the missile field, with complete familiarity with high speed oscillography; pin techniques; pulse circuitry techniques; high speed photography; and instrumentation methods for recording pressure; shock; velocity and temperature for the development of ordnance equipment for missiles.

Advanced degree required and Ph.D. preferred in E.E., physics or chemistry and evidence of creative, original work through published articles, patents or superior Ph.D. theses for research work in one or more of the following: thermoelectric; photovoltaic; lumistor; ferrite; logic component; sensor; thermistor; or cryogenic devices. Also, materials analysis and evaluation; processing techniques design and development of novel electronics devices and components; circuit analysis; circuit topology; or microminiaturization.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for Navy POLARIS FBM; DISCOVERER, MIDAS and SAMOS; Army KINGFISHER; Air Force Q-5 and X-7

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIF. • CAPE CANAVERAL, FLA. • ALAMOGORDO, N.M. • HAWAII



"decision makers" at Motorola are engineers like you...

At Motorola, friendly cooperation is a way of life. The "chain of command" (right to the top) talks your language – and backs you up with shirt-sleeve action. You'd be working in a *truly* professional climate that encourages you to explore, create and contribute.

These are some of the prime reasons why our *project approach* to military electronic assignments enjoys such solid success. Current expansion has created a number of diversified positions offering great opportunities for professional progress. And . . . if you also like the idea of living under sunny Arizona skies, write today to Mr. Bob Worcester, Professional Personnel Representative, Dept. C-12

OPPORTUNITIES

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System Analysis, Design & Test
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Combat Surveillance • Communications
Field Engineering • Data Processing and Display
Circuit Design, Development and Packaging
Microwave • Pulse and Video
Antenna • Transistor • R-F and I-F
Servos • Digital and Analog
Technical Writers and Illustrators, Quality Control Engineers, Reliability Engineers

MOTOROLA

Western Military Electronics Center 8201 E. McDowell Rd., Scottsdale, Arizona

Motorola also offers opportunities at Riverside, California and Chicago, Illinois

Positions Wanted

By Armed Forces Veterans

(Continued from page 174A)

ELECTRONIC ENGINEER

BSEE. 1956 from Louisiana Tech. Professional Engineer, La.; FCC license; 3 years in radio equipment research and development. Desires diversified work involving planning and circuit work. Age 25; married; USAF officer; January 1960. Box 2044 W.

INSTRUMENTATION

Group Leader: instrument development for product improvement; development of unique applications of sound, light and electronics to measurement of various process parameters; and development of automatic equipment. 13 years experience; BS. Eng. Physics, MS. Electrical Engineering. Box 2045 W.

ENGINEER

Ph.D., June 1960, 5 years industrial experience, several semesters experience teaching lecture courses at the senior EE level. Interested in teaching and research at progressive EE dept. Prefer western U.S. Box 2049 W.

SYSTEM ENGINEER

3 years engineering experience in digital and analog system development. 2 years technician experience in switching. 4 years USAF Nuclear Weapons. Interested in system engineering especially hybrid systems for control and data processing. Tau Beta Pi, Eta Kappa Nu. Available on completion of M.E.E. requirements, June 1960. Age 28, married, 2 children. Box 2050 W.

SENIOR ENGINEER—CHIEF

Age 43; broad electronic experience with vacuum tube and transistor circuitry, analog computers, gyro systems, power supplies, miniaturization and printed circuitry. Senior Member IRE. Tau Beta Pi, Eta Kappa Nu. Will relocate for an outstanding opportunity. Box 2051 W.

ENGINEERING TEACHER

BS. and MS. in E.E. 2 years industrial research, 2 years applicable military, and 4 years full-time teaching on the faculty of a major east coast university. Desires position of permanent with good family living conditions. Summer income opportunity desirable. Available June 1960. Box 2052 W.

ELECTRICAL ENGINEER

BS. in physics, graduate work in E.E.; 7½ years experience in electronics of which 3½ years is in commercial data processing. Have published articles and hold patents in electronics. Desires overseas position. Box 1053 W.

ENGINEER

BSEE., extensive antenna and R.F. experience, design and project supervision. Broad background includes sales and engineering management, contract negotiations. Desires position as General Manager of antenna company, or participant in ownership management of antenna consulting firm or small growing company. Box 2054 W.

COMPONENTS ENGINEER

E.E. degree. 10 years solid experience in electromechanical components—development, evaluation, application and standardization. Desires a challenging, responsible position in a supervisory capacity, New York, Long Island area preferred. Box 2055 W.

(Continued on page 180A)

AN EXTRAORDINARY TRANSISTOR

This tiny silicon chip does something no other transistor can do. It achieves the speed of the fastest germanium plus having the superior temperature characteristics and reliability inherent to silicon. It is the Fairchild 2N706.

This extraordinary transistor was introduced to industry in August of 1959. Within two months, many thousands of units had been shipped and the 2N706 was being designed into highest performance computer circuits. No "blue sky" project, the 2N706 is applicable and extremely advantageous to all types of high speed computer logic.

The 2N706 is also extraordinary as a success story in people—solid-state physicists, physical chemists, metallurgists, electrical engineers, mechanical engineers and industrial engineers. Free flow of ideas and enthusiasm produced an accumulation of advanced semiconductor technologies at an unprecedented rate. From the beginning, only two years ago, the 2N706 was the goal. En route, these technologies resulted in the production of eight other silicon transistors. These devices have clearly established Fairchild as the leader in advanced semiconductor development.

Step by step, the Fairchild program was planned and held in focus by a top management team of advanced degree scientists. And now, this same program is being zeroed in on new targets, among them Esaki diodes and integrated solid-state circuitry. If yours is a relevant background and you like the way we work, why not drop us a line? We would like to hear from you.

FAIRCHILD
SEMICONDUCTOR CORPORATION

545 WHISMAN ROAD/MOUNTAIN VIEW, CALIFORNIA/YORKSHIRE 8-8161

SENIOR STAFF SPECIALISTS

Positions are open in Honeywell's Aeronautical Division for three qualified senior engineering specialists. Duties are 1) to guide development and design projects in the application of advanced techniques to Honeywell designs; and 2) provide technical assistance in specialty areas for selection and execution of new system and new product developments.

For these openings, advanced engineering study and relevant military experience will be valuable. These are not purely advisory positions. Those men chosen will be expected to participate actively in the execution of Division Engineering Programs.

WEAPON DELIVERY AND CONTROL SYSTEM COMPUTERS

Background of computer and system development for bombing, fire control, or navigation. Experience with analog and digital systems, tie-ins, weapon characteristics, and performance determination.

RADAR AND RELATED SYSTEMS

Background of airborne system engineering in one or more areas such as AMTI, doppler, monopulse, ECM, CCM, infrared, and communications. Experience should include responsibility for establishing system configurations, technical development, and evaluation.

ELECTRONIC CIRCUITS

First-hand knowledge of design techniques for advanced circuits—dc, low frequency, pulse, and r.f.—for control, computation, measurement, and communication. Must be knowledgeable with respect to solid state devices and circuits and interested in making major contribution to Division application of microcircuit techniques.

To arrange an interview, write to

J. R. Rogers, Chief Engineer,
Preliminary Development Staff, Dept. 154

MINNEAPOLIS
Honeywell
AERONAUTICAL DIVISION
2600 Ridgway, Minneapolis 13, Minnesota

To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. D. Eckstrom, Honeywell, Dept. 154, Minneapolis 8, Minnesota.

Positions Wanted

By Armed Forces Veterans

(Continued from page 178A)

ELECTRONIC FIELD ENGINEER

Graduate engineer, BSEE., several years experience, age 32, fair health, seeking position as electronic engineer—sales engineer, field engineer, coordinator customers' technical requirements either commercial or military customers, or supervisor equipment installation and installation checkout. Preparation with company training course desirable. Box 2056 W.

ENGINEERING MANAGER—TECHNICAL REPRESENTATIVE

Retiring Navy Captain. Engineering Duty Officer. Senior Member IRE. Desires to locate in Southern California. Graduated Naval Academy 1926. 3 years sea duty, 12 years civilian electronics engineer. Returned to active duty 1941; 9 years technical administrator in Naval laboratories; 4 years comptroller in Naval Shipyard with collateral duty as project officer for electronic data processing; available late spring 1960. Box 2057 W.

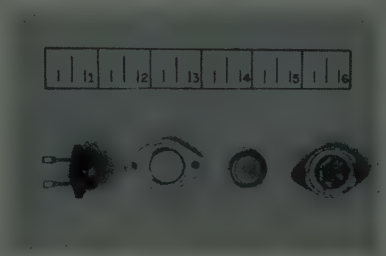
NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 156A)

Military-Type Transistor

Military-type 2N120, a high current, high-power switching transistor—is now in production by **Bendix Aviation Corp.**, Semiconductor Products, Long Branch, N. J.



The 2N1120 has been designed to meet the specification MIL-T-19500/68 (SigC). Its maximum collector current rating of 10 Adc makes it particularly appropriate for high current switching applications, while a collector-emitter voltage rating of 70 Vdc suits it equally well to high voltage applications. The 2N1120 will readily dissipate 45 watts at a 25°C mounting base temperature. Subjected to the environmental testing required by the specification, this transistor has the high reliability demanded in military applications.

For further information, contact Marketing Department.

(Continued on page 184A)

WITH ONLY MINUTES TO ACT

If America should be attacked . . . from bases around the world Strategic Air Command bombers, tankers and surface-to-surface missiles will rise to action. Minutes only will be available.

To integrate and control this assault requires accessibility and handling of a staggering volume of data. In the missile era, present methods of gathering and processing data will be inadequate. SAC is automating the system.

As systems manager, International Electric Corporation is developing and will turn over to SAC a world-wide electronic combat control system, an integrated complex of electronic subsystems. The system, employing digital techniques and equipment, will transmit, process and display information on a global basis . . . with only seconds involved.

Engineers whose interests lie in systems engineering, data processing and communications will find in this long-term project exceptional opportunity to exercise creative competence and individual initiative. For details of engineering assignments write B. J. Crawford, Director of Technical Staffing.

INTERNATIONAL ELECTRIC CORPORATION
An Associate of International Telephone and Telegraph Corporation
Route 17 & Garden State Parkway, Paramus, New Jersey

What makes a missile tick?

At Raytheon, successful design and development of advanced missile weapons systems are the result of a closely knit *team effort* . . . the combined contributions of many engineering minds. And at Raytheon, Missile Engineers enjoy the exceptional rewards and advantages offered by its largest and fastest growing division.

Location: Bedford, Mass. Suburban New England living . . . only minutes from Boston's unexcelled educational opportunities. Relocation allowance. Pick *your* spot on the Raytheon team. Immediate openings for Junior and Senior Engineers with missile experience in the following areas:

MICROWAVE DESIGN
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COMMUNICATIONS SYSTEMS
DIGITAL PROGRAMMING
GUIDANCE SYSTEMS
RADOME DESIGN
COMPUTER SYSTEMS
HEAT TRANSFER
RADAR SYSTEMS
OPERATIONS ANALYSIS
INERTIAL REFERENCE SYSTEMS
FEED-BACK CONTROL
AUTO-PILOT
GROUND SUPPORT
ELECTRONIC PACKAGING
TEST EQUIPMENT DESIGN
ELECTROMECHANICAL ENGINEERING
(Background in missile control and auto-pilot design)
MECHANICAL ENGINEERING
(Background in ground handling of large missile systems)
MICROWAVE TUBE DESIGN

Please send resume to Mr. W. F. O'Melia, Employment Manager, Raytheon Company, Bedford, Massachusetts, or call collect: CRestview 4-7100, Extension 2138.

RAYTHEON MISSILE SYSTEMS DIVISION

URGENT!

ELECTRONIC CIRCUIT AND PACKAGING ENGINEERS

NO FEES TO $14,000

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BEYOND THE RIM

Today mankind is embarked on the most exciting voyage of discovery since Columbus sailed beyond the rim of the known world.

In a physical sense, it is a voyage that ranges from investigation of the infinitesimal components of matter to exploration of the vastness of the cosmos.

But at Sandia Laboratory it is a voyage of the mind — a voyage beyond the rim of our present comprehensions, to unlimited destinations.

At our laboratories in Albuquerque, N. M. and Livermore, California, we perform research and development pertaining to nuclear weapons and certain allied non-military projects for the Atomic Energy Commission. We need men with the knowledge, the experience, and the desire to venture beyond the rim in many fields of science and engineering. At present, we have challenging opportunities in these specific fields:

PHYSICS and MATHEMATICS — Scientists at PhD level for both fundamental and applied research, at Albuquerque and Livermore.

EXPLOSIVES CHEMISTRY — Chemists or chemical engineers with advanced degrees and extensive experience in this field, at Albuquerque.

STATISTICS — Experienced statisticians with MS or PhD degrees and interest in statistical methods and quality control, particularly in statistical design of experiments. Required at Albuquerque only.

QUALITY CONTROL — Industrial, mechanical, and electrical engineers with experience in quality control methods development and training assignments, at Albuquerque only.

STRESS ANALYSIS — Experienced mechanical or aeronautical engineers, preferably with advanced degrees, at both Albuquerque and Livermore.

HUMAN ENGINEERING — Experienced personnel with advanced degrees in psychology plus engineering degrees, at Albuquerque only.

ELECTRICAL or MECHANICAL DESIGN and DEVELOPMENT ENGINEERING — Experienced personnel with BS or MS degrees, at both Albuquerque and Livermore.

AERODYNAMICS — Research and development in the fields of space and high-altitude rockets; hypersonic research; magnetic theory; supersonic parachutes; nuclear weapon aerodynamics; and high velocity research apparatus design, at Albuquerque.

MANUFACTURING DEVELOPMENT ENGINEERS — Electrical, Mechanical or Industrial degrees — to be in charge on a nationwide basis of products during the manufacturing phase, at Albuquerque only.

COMPUTER ENGINEERS — Engineers at the MS or PhD level with three to five years experience in advanced computer systems, digital techniques or control system design, at Albuquerque only.

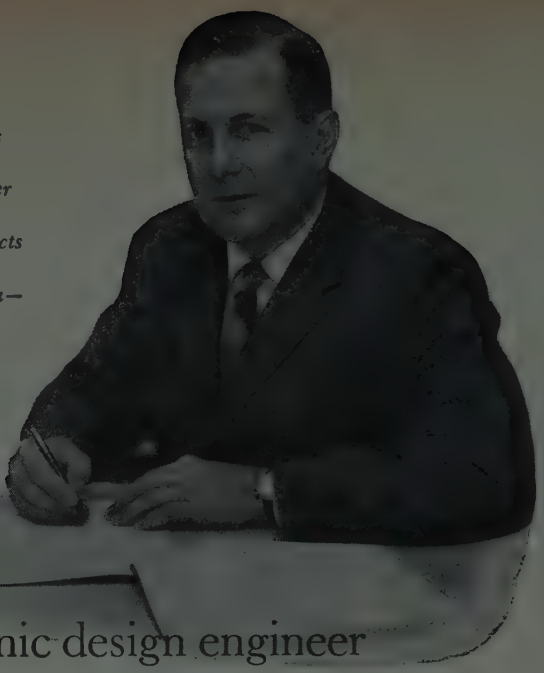
Sandia Laboratory offers many advanced and specialized facilities to further work of its scientists and engineers. Liberal employee benefits, including generous vacations and holidays, insurance and retirement plans, educational aid program, add to Sandia's attractiveness as a place to work. Albuquerque, a city of over 225,000 with a mild, dry climate and friendly Southwestern atmosphere, is a delightful place in which to live. Livermore, located in the San Francisco Bay area, offers suburban advantages close to metropolitan San Francisco.

IF YOU ARE INTERESTED in a career at Sandia, our illustrated brochure will tell you more about the opportunities we offer to advanced scientists and engineers. Write to Employment Section 554G at either Albuquerque, N. M., or Livermore, California.

SANDIA CORPORATION

ALBUQUERQUE, NEW MEXICO

A message to Electronic Engineers from R. P. Gifford, Engineering Manager of General Electric's Communication Products Department in Lynchburg, Virginia—



"An electronic design engineer earning $10,000 should be a decision-maker *beyond* his project's immediate technical problems."

"I believe that any electronic design engineer earning $10,000 or more welcomes the authority to make a variety of high-level business decisions—in such areas as features versus cost and reliability versus weight—working closely, of course, with his marketing counterparts in Product Planning and also with the Manufacturing Engineers.

"At Communication Products Department we give the experienced engineer the *necessary authority* to do just this. He generally enters the design project early in the development planning phase, so that he can take responsibility for estimating the project expense and schedule—thus contributing to the establishment of bogeys for product cost and delivery.

"Of course our communication systems must do the customer's job, but also they must be *marketable at a profit to the Department;* to make this come true is a vital part of the design engineer's challenge. This means exposure to many management problems and a rare opportunity to grow and move ahead rapidly.

"Our communication products are primarily commercial, including Mobile Radio, Microwave Radio Relay, Terminal Equipment, Telephone Carrier, Multiplex, and Personal Communication Systems. Military contracts also in the house include a 24-channel SSB tropospheric scatter system."

Right now, we have immediate openings for Advance, Development, and Systems Engineers who have significant backgrounds in these areas:

R.F. circuit design
Multiplex equipment
Microwave systems design
Solid state devices
Microwave plumbing, antennas
Piezoelectric devices
Mobile transmitter, receiver design
Electronic equipment mechanical design
Automatic test equipment D&D
Microminiaturization

For prompt consideration, forward your resume in confidence to Mr. C. Fullmer, Dept. 53-ML
COMMUNICATION PRODUCTS DEPARTMENT

GENERAL ELECTRIC

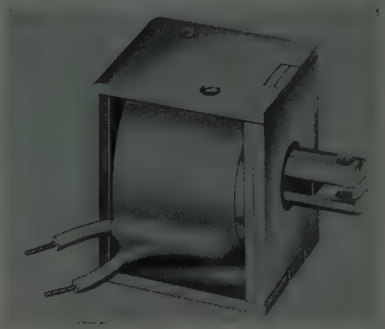
Mountain View Road, Lynchburg, Virginia

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 180)

AC or DC Solenoid



Guardian Electric Mfg. Co., 1621 West Walnut St., Chicago 12, Illinois, has developed a new (No. 28) Midget Solenoid, available ac or dc, intermittent or continuous duty, which the company claims will be of interest to design engineers, because of its size, power and versatility. This solenoid has tapered plug and plunger for greater power. Plunger strokes from $\frac{1}{16}''$ to $\frac{1}{2}''$ with a lift of over 41 ounces. Overall dimensions: $1\frac{1}{8}'' \times 1'' \times 1\frac{3}{16}''$. Weight: approximately $3\frac{1}{2}$ ounces. For further information write to Guardian.

(Continued on page 186A)

ASSISTANT CHIEF INSTRUMENT ELECTRONICS

To assist in directing development of precision accelerometers, digital velocity meters and other inertial instrumentation. Experience with transistorized circuitry development desired.

To arrange interview call collect, Niagara Falls BUtler 5-7851, or send resume to:

Supervisor Engineering Employment

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ENGINEERS

As part of a continuing program of scientific inquiry, the Research Laboratories of United Aircraft Corporation are again expanding their activities.

The record of this organization over the past thirty years has shown a consistent trend toward basic research. The present expansion is part of this pattern and offers Scientists and Engineers a unique opportunity for creative work coupled with job stability. Independence of scientific thinking and action are encouraged.

Our unusual complex of supporting services includes: modern laboratories and equipment, the nation's largest industrial digital and analog computing facility and a coordinated program for the design and development of advanced instrumentation.

If you feel you can make creative contributions in the following fields of research . . .

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Gaseous Electronics
Nuclear Engineering
Cryogenics
Energy Conversion
Instrumentation
Electrical Propulsion

Please write
Mr. W. M. Walsh
or phone
Hartford, Conn.
JAckson 8-4811
Ext. 7145

. . . and if you are now limited to ordinary problems—only partially using your training and abilities—these openings should be of particular interest.

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UNITED AIRCRAFT CORPORATION
400 Main Street, East Hartford 8, Connecticut

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DOUGLAS AIRCRAFT COMPANY
MISSILES AND SPACE SYSTEMS

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- Antenna & Radome Design
- Radar System Analysis and Design
- Instrumentation
- Equipment Installation
- Test Procedures
- Logic Design
- Power System Design

Mechanical Engineering—
Analysis and Design of the following:
- Servo Units
- Hydraulic Power Systems
- Air Conditioning Systems
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NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 184A)

Rotary Switch Bulletin

A bulletin on the new High Precision Rotary Switch WP-2 recently brought out by **Waters Manufacturing, Inc.**, Wayland, Mass., is now available. Illustrations are actual size. Electrical, mechanical and environmental specifications including a dimensional schematic are also given.

Ground Support Equipment Catalog

Ground support equipment systems, components and capabilities for aircraft and missiles are described in a new four-page brochure which is available from **Lear, Inc., Contracts Div.**, P.O. Box 688, Grand Rapids 2, Mich.

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(Continued on page 216A)

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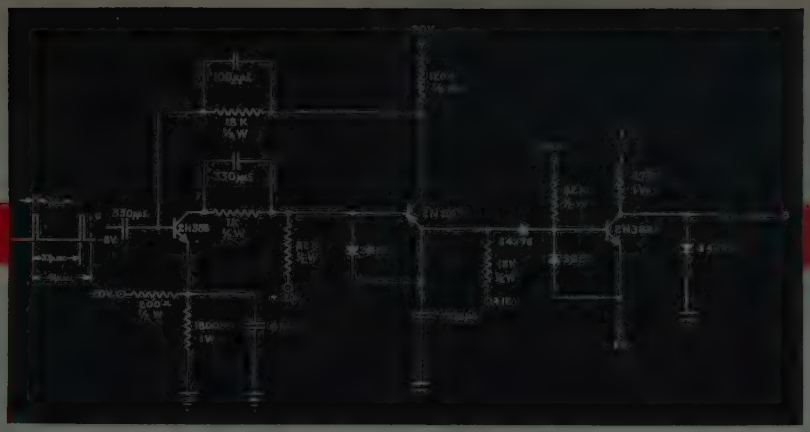

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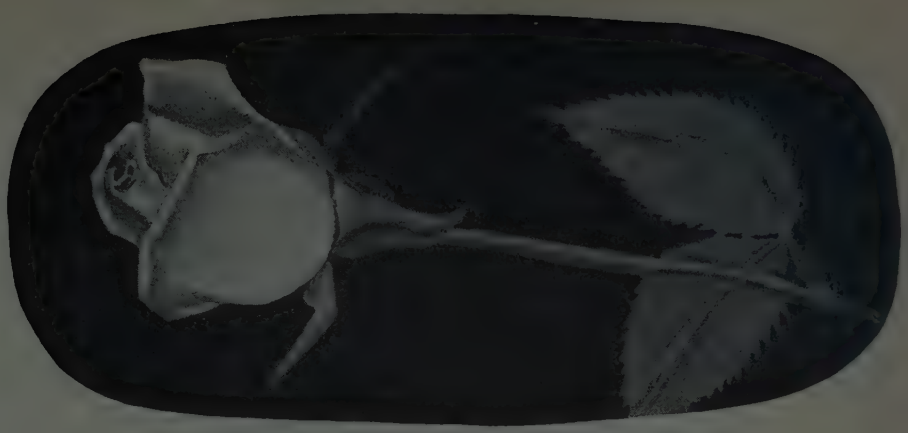

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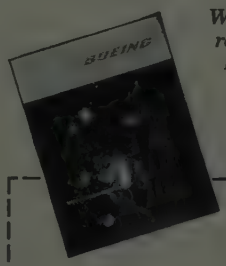

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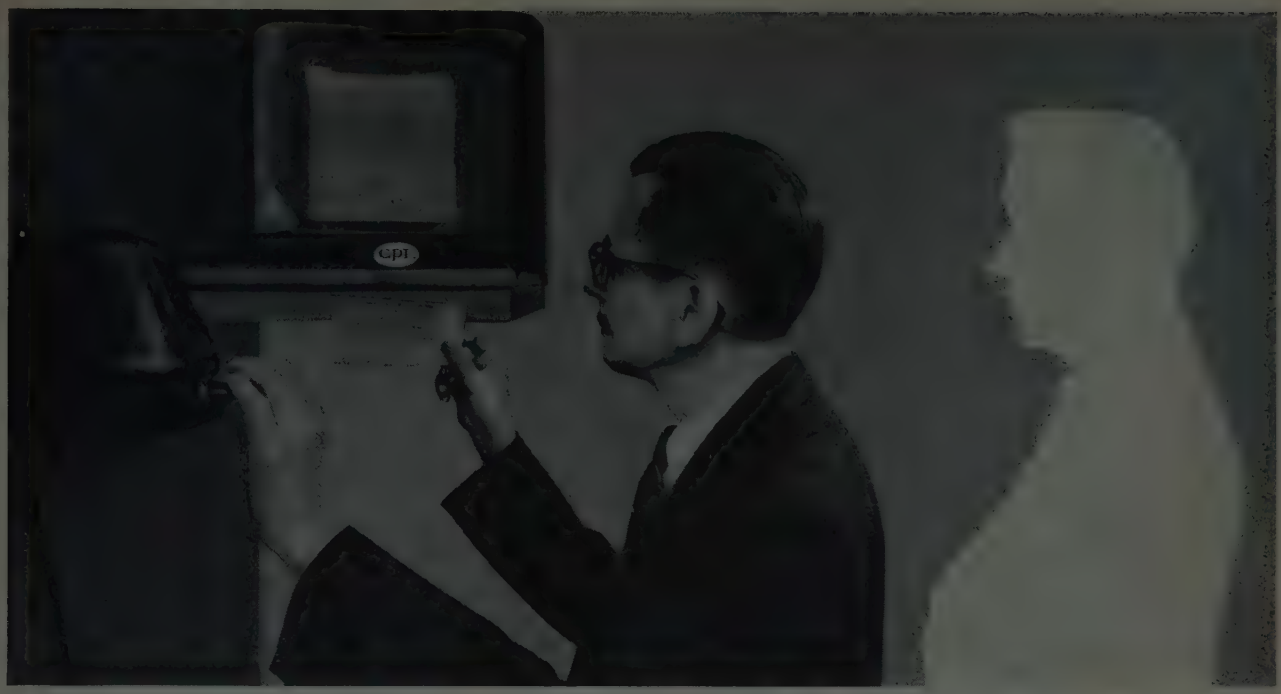

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(Continued on page 198A)

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(Continued on page 200A)

IMPORTANT DEVELOPMENTS AT JPL

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A fundamentally new type of gyroscope with the possibility of exceptionally low drift rates is currently under development. The design techniques used in conventional electro-mechanical gyros appear to have been largely exploited. A break-through is needed, and the cryogenic gyro may well provide it.

The cryogenic (liquid helium temperatures, in the range of 4°K) gyro consists of a superconducting sphere supported by a magnetic field. The resulting configuration is capable of support in this manner as a result of a unique property of a superconductor. Exceptionally low drift rates should be possible. This cryogenic gyro has performance potential unlimited by the constraints of conventional electro-mechanical gyros.

This is just one example of the intriguing solid state concepts which are being pioneered at JPL for meeting the challenge of space exploration. In addition to gyro applications, superconducting elements are providing computer advances and frictionless bearings. The day of the all-solid-state space probe may be nearer than one realizes.

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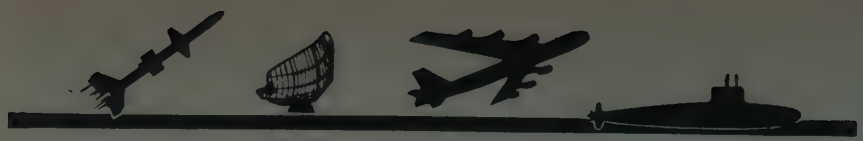

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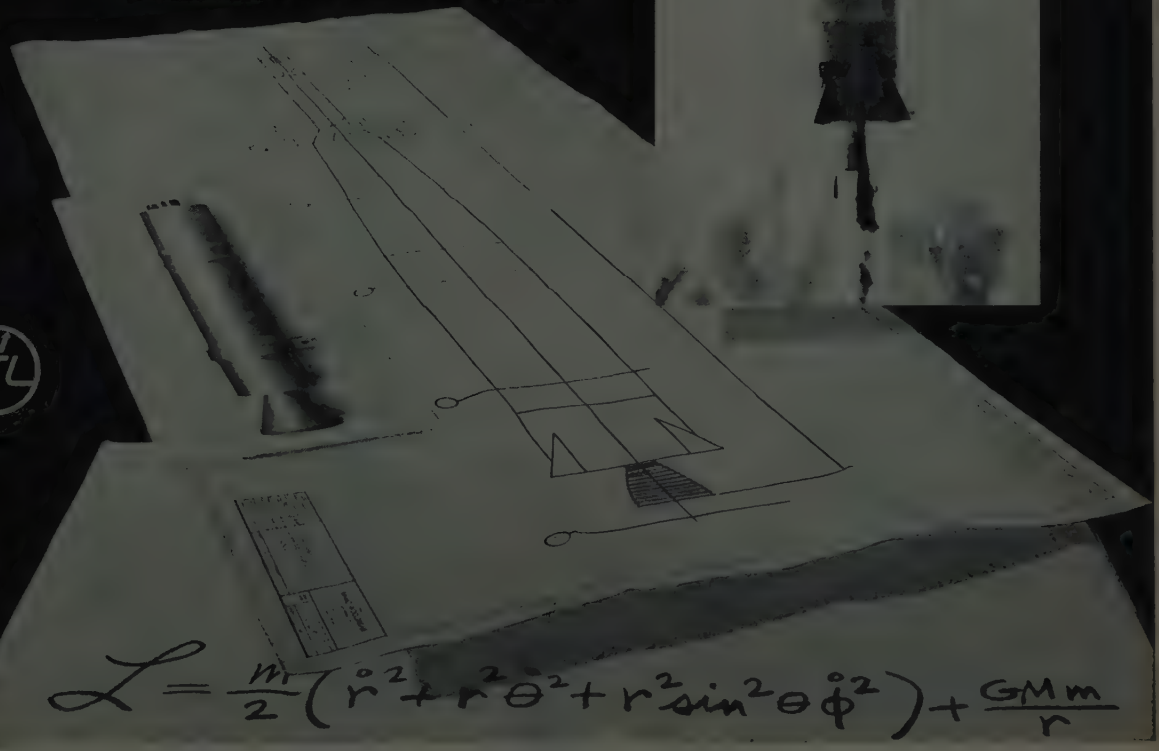

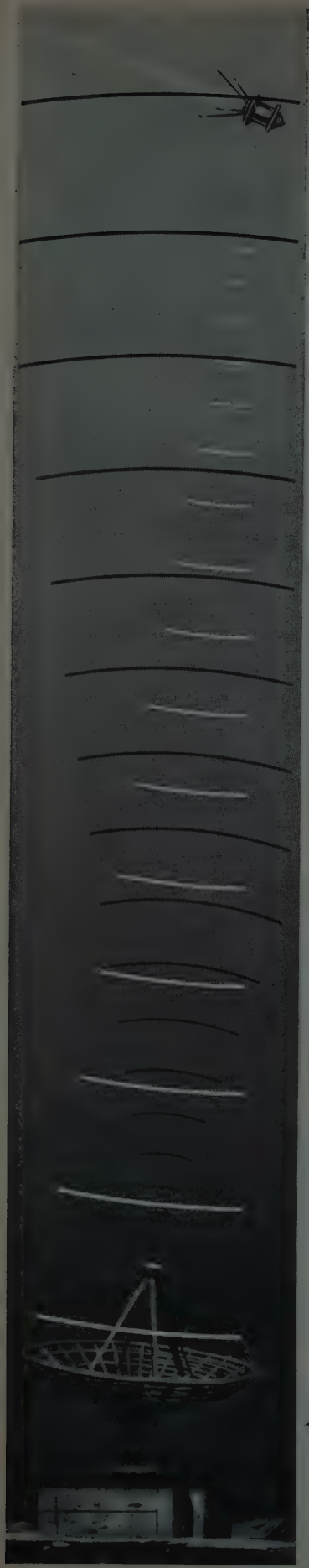

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(Continued on page 206A)

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4 *Advanced Radar Systems Analysis and Development Engineer:* Engineers are needed who are able to visualize and define future defense and space problems—conceive advanced radar systems to solve them. An advanced degree and/or strong background in system analysis and design is essential. Assignments open include: analyze and define requirements for advance detection systems and determine broader parameters for such systems, establish their feasibility; analyze long range missile detection systems and specify optimum configuration on the basis of utility, performance, cost and delivery. 228-9

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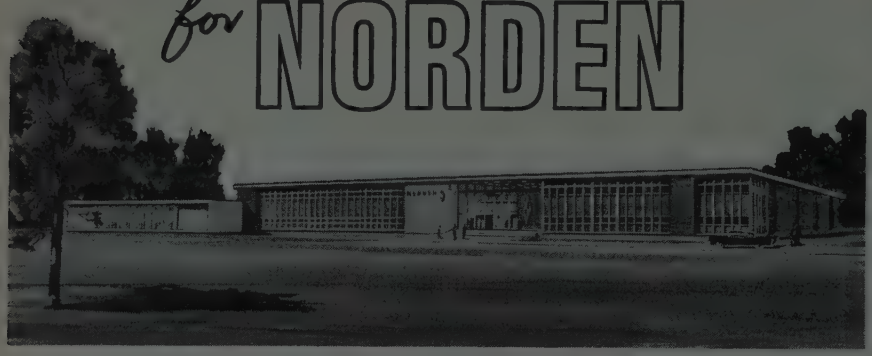

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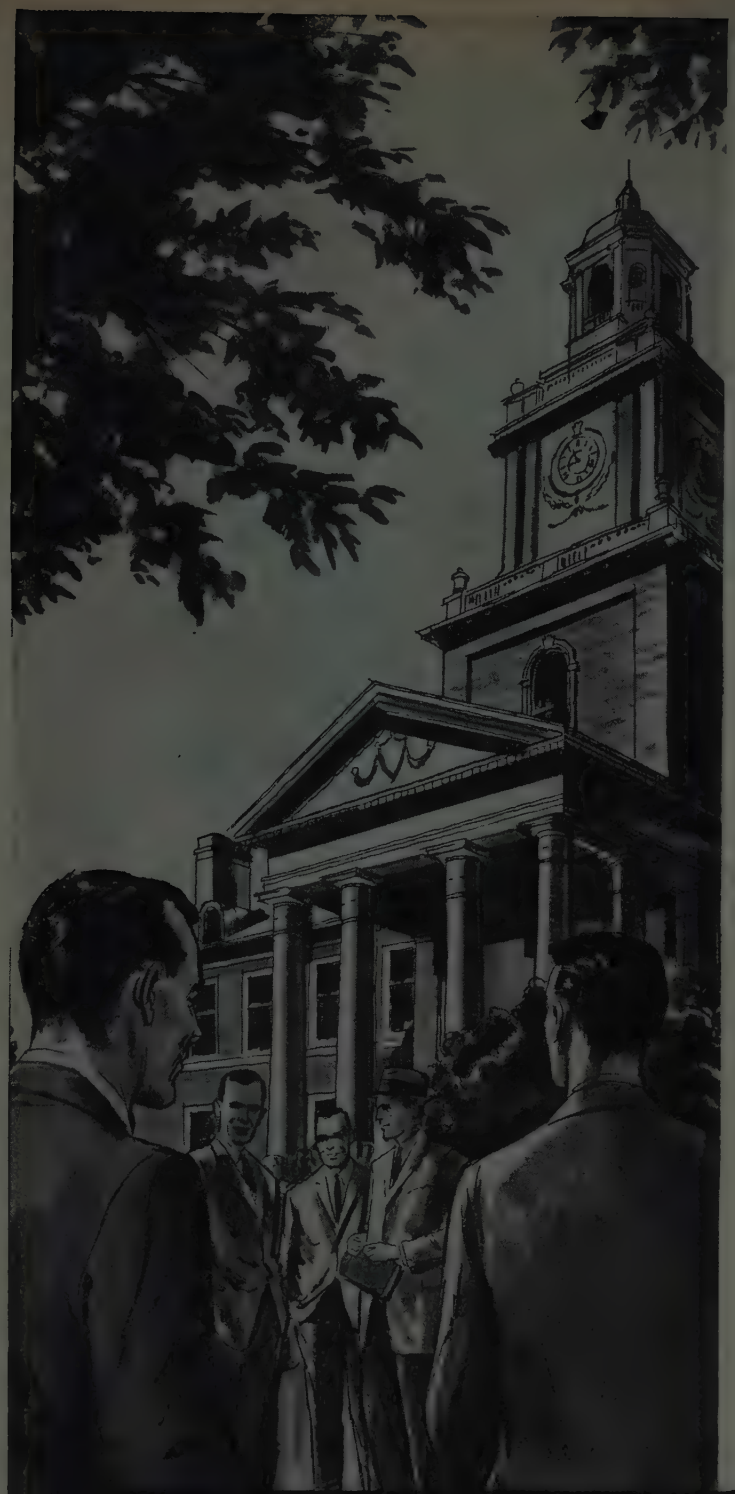

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(Continued from page 202A)

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(Continued on page 208A)

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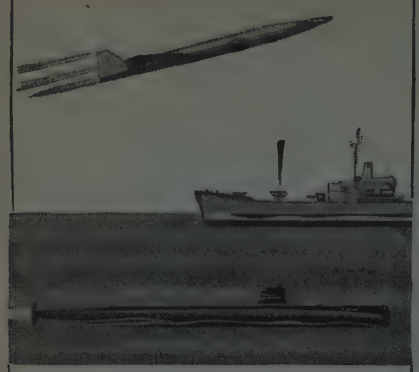

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Kantor, P. M., Massapequa, N. Y.
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(Continued on page 210A)

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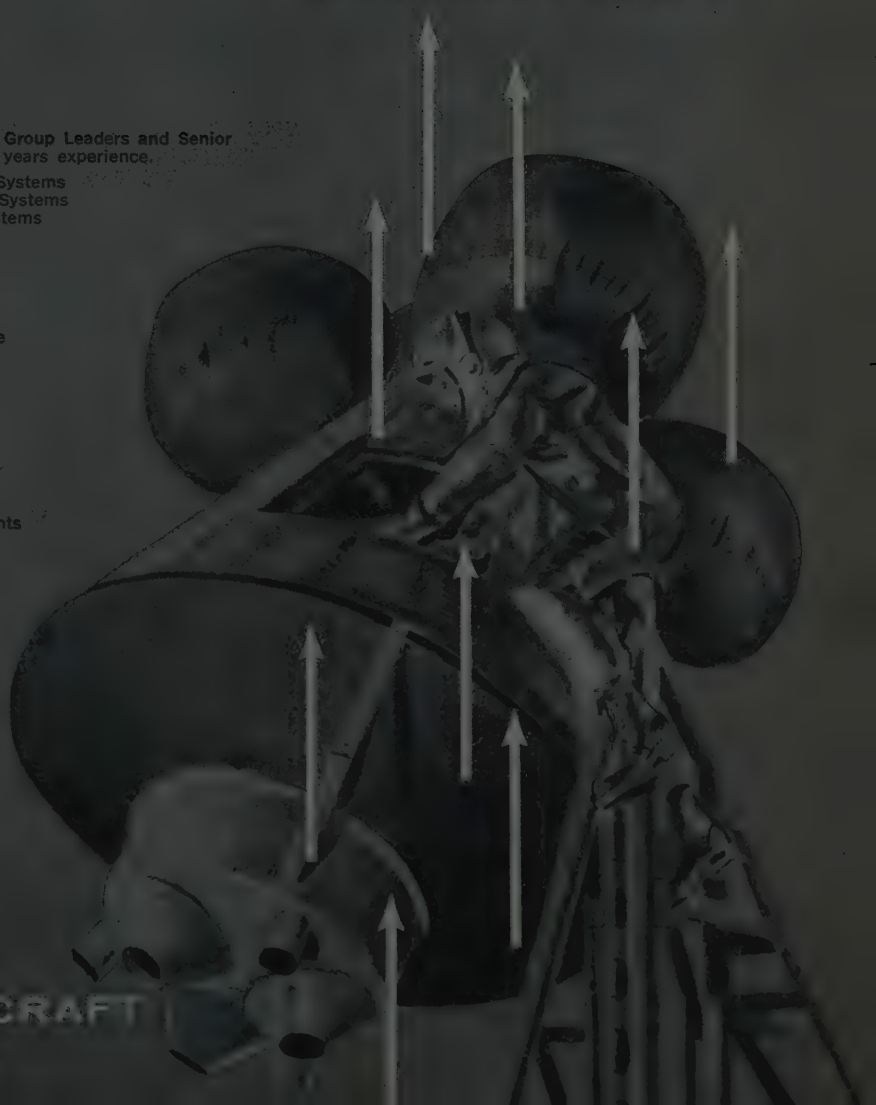

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Meskill, W. D., San Antonio, Tex.
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Millican, G. L., Dallas, Tex.
Mliner, G., South Milwaukee. Wis.
Molfino, A. A., Milano, Italy
Monahan, W. R., Pelham, N. Y.
Moore, M. J., Cocoa Beach, Fla.
Morcott, T., Palo Alto, Calif.
Morris, F. M., Toronto, Ont., Canada
Mosser, F. D., Cocoa Beach, Fla.
Mountz, J. M., Oak Park. Ill.
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Murray, J. T., Fairfax, Va.
Murray, P. C., Waltham, Mass.
Nanni, B., The Hague, Netherlands
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Painter, H. O., Jr., West Concord, Mass.
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Payne. R. C., Shreveport, La.
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Pedneau, W. F., Metairie, La.
Perkins, T. J., Palo Alto, Calif.
Phillips, W. M., Dallas, Tex.
Podolski, G. A., Levittown, Pa.
Poe, W. R., Las Vegas, Nev.
Pollock, K. G., Corning, N. Y.
Pradenas, F., Corte Madera, Calif.
Pribble, H. A., Jr., Claremont, Calif.
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Puskorius, J., Euclid, Ohio
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Quail, S. E., Highland Mills, N. Y.
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Reagan, J. A., Albany, N. Y.
Rich, S. F., Hawthorne, Calif.
Richardson, J. D., Johnson City, N. Y.
Rienzo, J. J. Jr., Reading, Mass.
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(Continued on page 212A)

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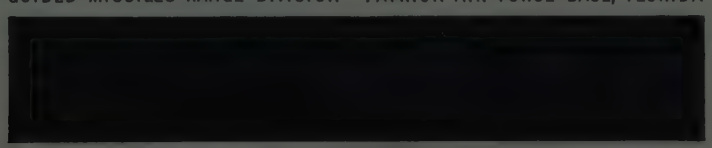

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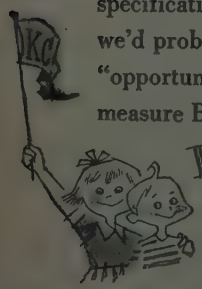

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(Continued from page 210A)

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Staluppi, J. P., Fairview, N. J.
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(Continued on page 214A)

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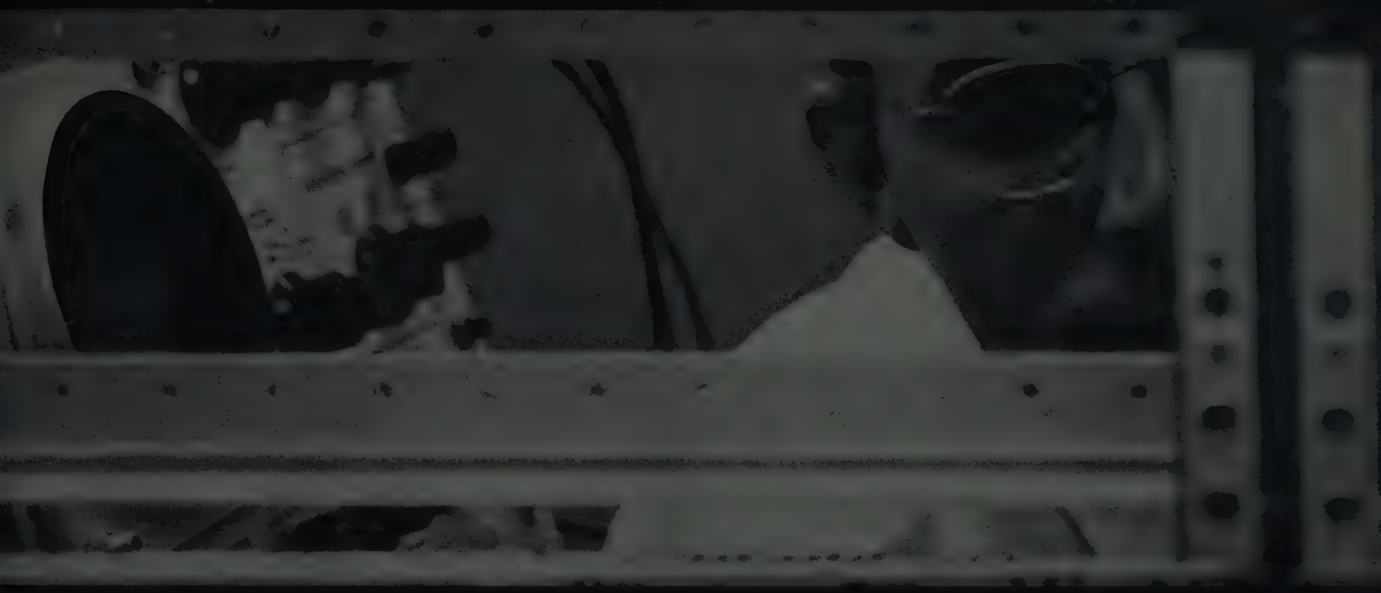

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NEWS New Products

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(Continued from page 186A)

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A new power monitor diode, manufactured by **Microwave Associates, Inc.**, Burlington, Mass., the MA-437 (1N2771) provides an accurate and inexpensive method of monitoring power output of RF generating devices in the 140 mc to 750 mc range. It is especially suited for communications and TV transmitters, and may be coupled directly to a microammeter for an accurate indication of transmitter RF power.

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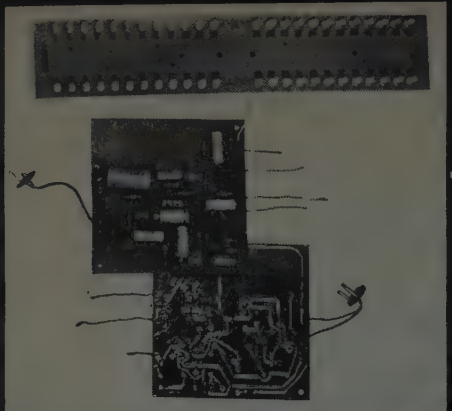

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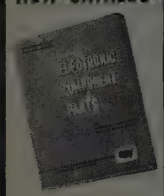

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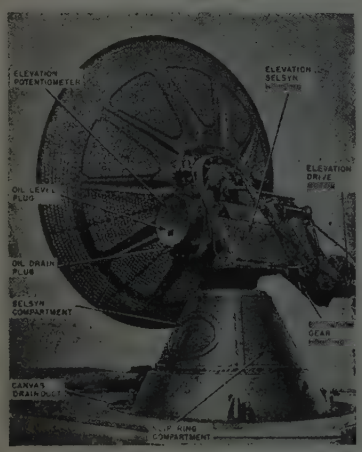

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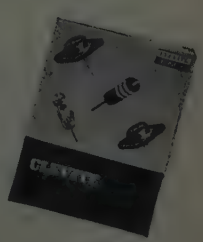

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1 Resistance changes due to humidity are temporary, but Allen-Bradley resistors can be returned to their original value by proper conditioning or "loading."

2 Resistance changes due to increase in moisture content are always positive.

3 Resistance change due to humidity varies with the resistance value and is less in the lower values.

4 Resistance change which has occurred due to humidity may be returned to the original value by conditioning the resistor at 100°C for 48 hours.

5 Resistors operating at 1/10 rated wattage load are hardly—if at all—affected by humidity.

6 Hermetically sealed resistors do not change because of humidity.

7 Resistance change due to "load life" is permanent and ultimately negative.

8 Resistance change due to "load life" can be minimized—on the order of 1% to 2% in many thousands of hours of service by derating the resistor approximately 50%.

9 This same result can be attained by limiting the maximum operating surface temperature of the resistor under load to 100°C.

10 Resistance change due to soldering is positive; but if the resistor is dry, it will return to its original value in a matter of hours.

11 The temperature characteristic of the Allen-Bradley resistor is positive above and below room temperatures between +10°C and +80°C ambient.

12 The temperature characteristic of the Allen-Bradley resistor is negligible from +10°C to +80°C ambient.

13 The voltage characteristic of the Allen-Bradley resistor is negative. It is less at elevated temperatures than at room ambient (+10°C to +80°C).

14 The voltage characteristic is less in low-value resistors than in high-value units—it is linear.

15 The voltage characteristic and the temperature characteristic tend to cancel one another in an Allen-Bradley resistor under average operating conditions where both voltage and temperature are present.

16 The "heat sink" to which a resistor is connected affects its rating. Resistors operated in parallel should be derated unless an adequate "heat sink" is provided.

17 The quality and reliability of Allen-Bradley resistors are exactly the same regardless of the "tolerances" for which the resistor is listed.

Allen-Bradley Co., 114 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

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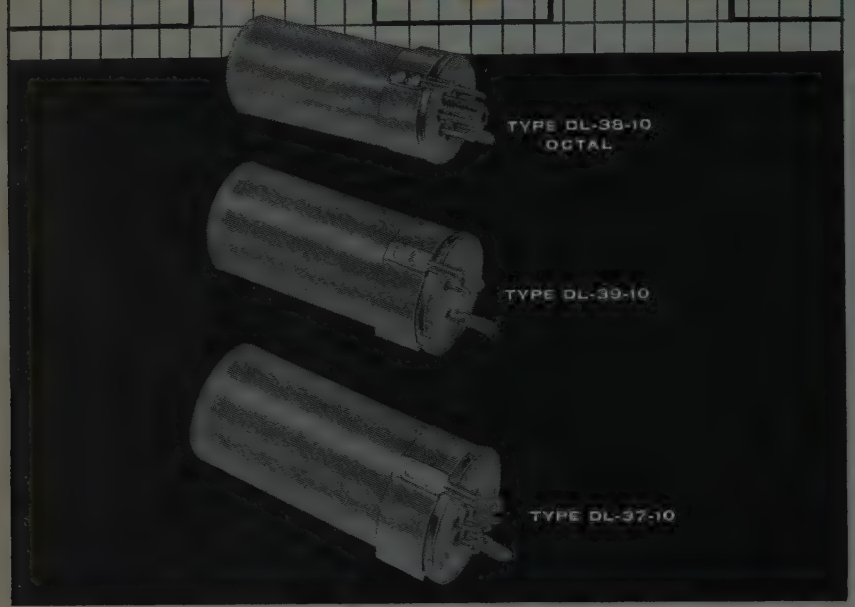
GK



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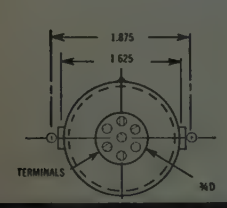
Delay Line design at Gray & Kuhn is characterized by units of uniquely high pulse fidelity, fast rise times and comparatively low amplitude losses ■ Operating within narrow delay tolerances in relation to cost and size limitation, Gray & Kuhn delay lines are in constant use on a variety of electronic, avionic and astronautic applications ■ The units above are of the Distributed Constant Phase Corrected type, hermetically sealed in drawn steel casings for maximum rigidity and humidity resistance ■ Gray & Kuhn also manufactures Lumped Constant Delay Lines for off-the-shelf shipment, in 36 types, varying in delay time, rise time and impedance ■

TYPE DL-37-10

COLOR CODE	DELAY TIME	RISE TIME
Violet	Input	
Orange	0.25 us	.11 us Max.
Yellow	0.5 us	.125 us Max.
Green	1.0 us	.175 us Max.
Blue	2.0 us	.22 us Max.
Brown	3.0 us	.255 us Max.
Red	Ground	

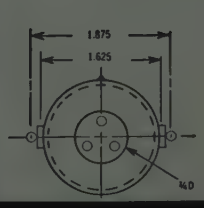


TYPE DL-38-10
OCTAL

PIN NO.	DELAY TIME	RISE TIME
1	Input	
2	0.25 us ±.03 us	.12 us Max.
3	0.5 us ±.03 us	.125 us Max.
4	1.0 us ±.05 us	.175 us Max.
5	1.5 us ±.05 us	.185 us Max.
6	2.0 us ±.05 us	.22 us Max.
7	3.0 us ±.05 us	.255 us Max.
8	Ground	

TYPE DL-39-10

Total Delay 3 us ±.05 us
Rise Time .255 us
Yellow Terminal — Input
Green Terminal — Output
Red Terminal — Ground



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- Low spurious residual FM.
- Accurate output voltage calibration.
- Operate at fundamental carrier frequencies.

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FREQUENCY RANGE: Seven standard models in the range from 25 to 480 Mc. Tuning ratio of 1.2 in most models.

FREQUENCY DEVIATION: Maximum of 25 Kc to 300 Kc depending on model.

OUTPUT VOLTAGE: 0.1 to 100,000 microvolts.

OUTPUT SYSTEM: Mutual-inductance attenuator. 50-ohm source impedance with low VSWR.

MODULATION: 400 and 1000 cycle internal audio oscillator. Other frequencies available.

MODULATION FIDELITY: Typical frequency deviation response ± 1 db from d.c. to 50 Kc, within 3 db to 100 Kc.

RESIDUAL FM: Spurious residual FM 60 db below 75 Kc deviation in most models.

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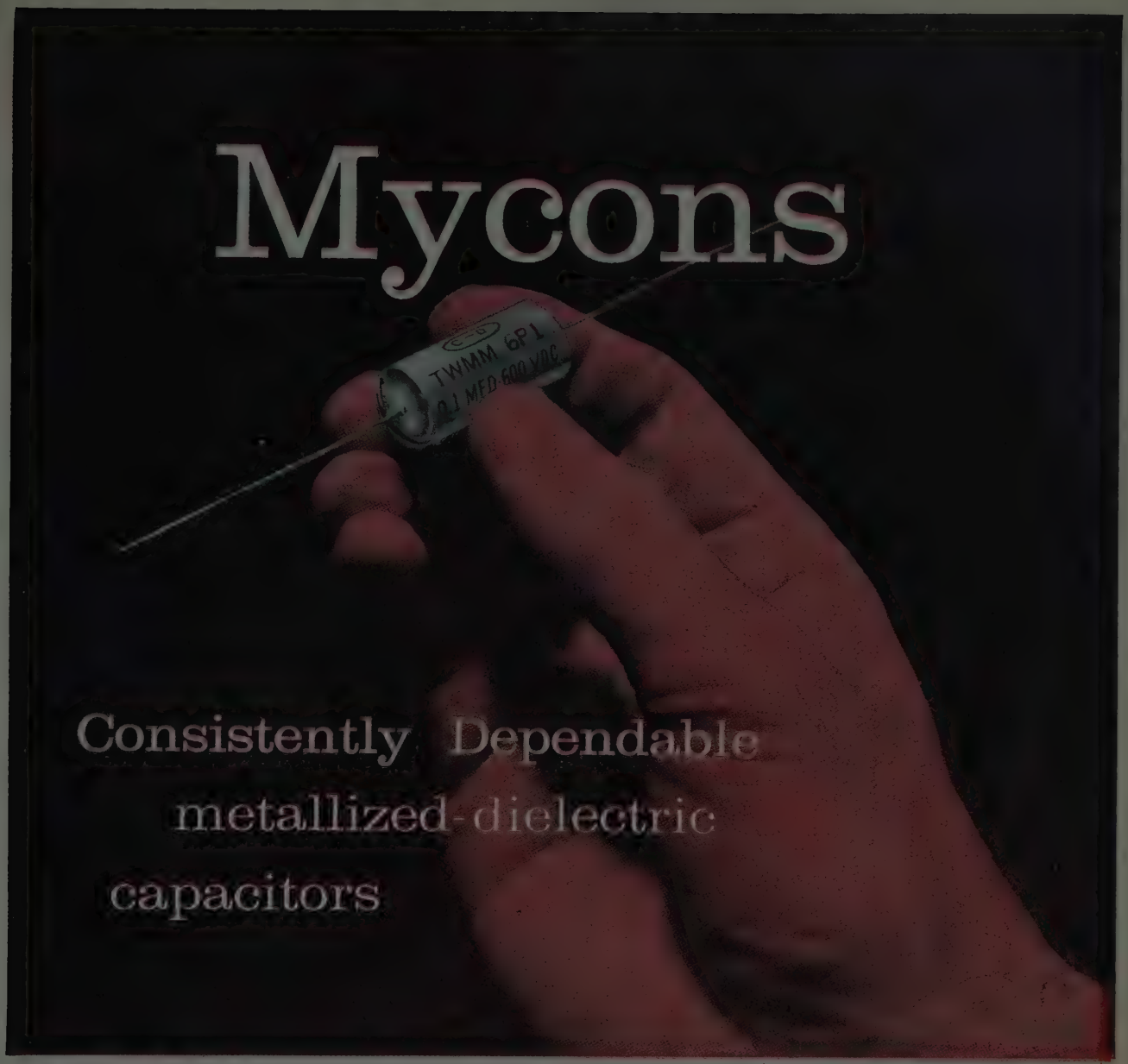

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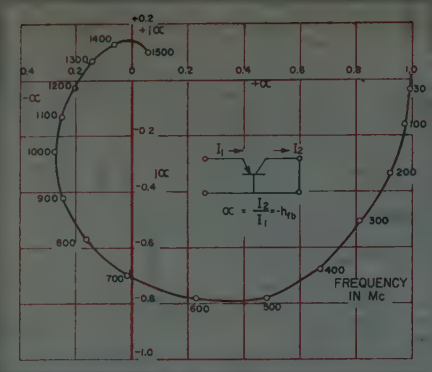
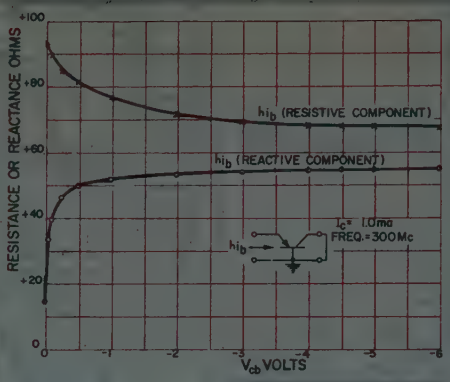
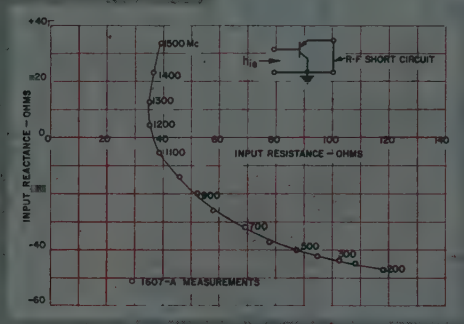


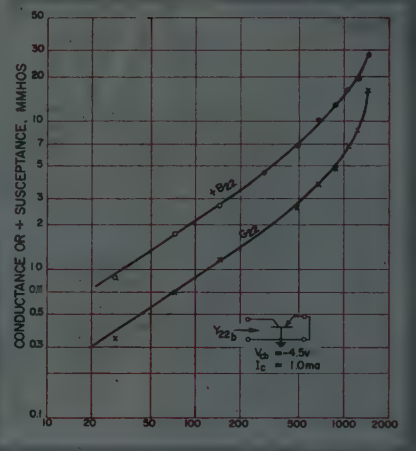
Plot of α, or $-h_{fb}$, versus frequency.



Variation of transistor parameters as a function of collector voltage.

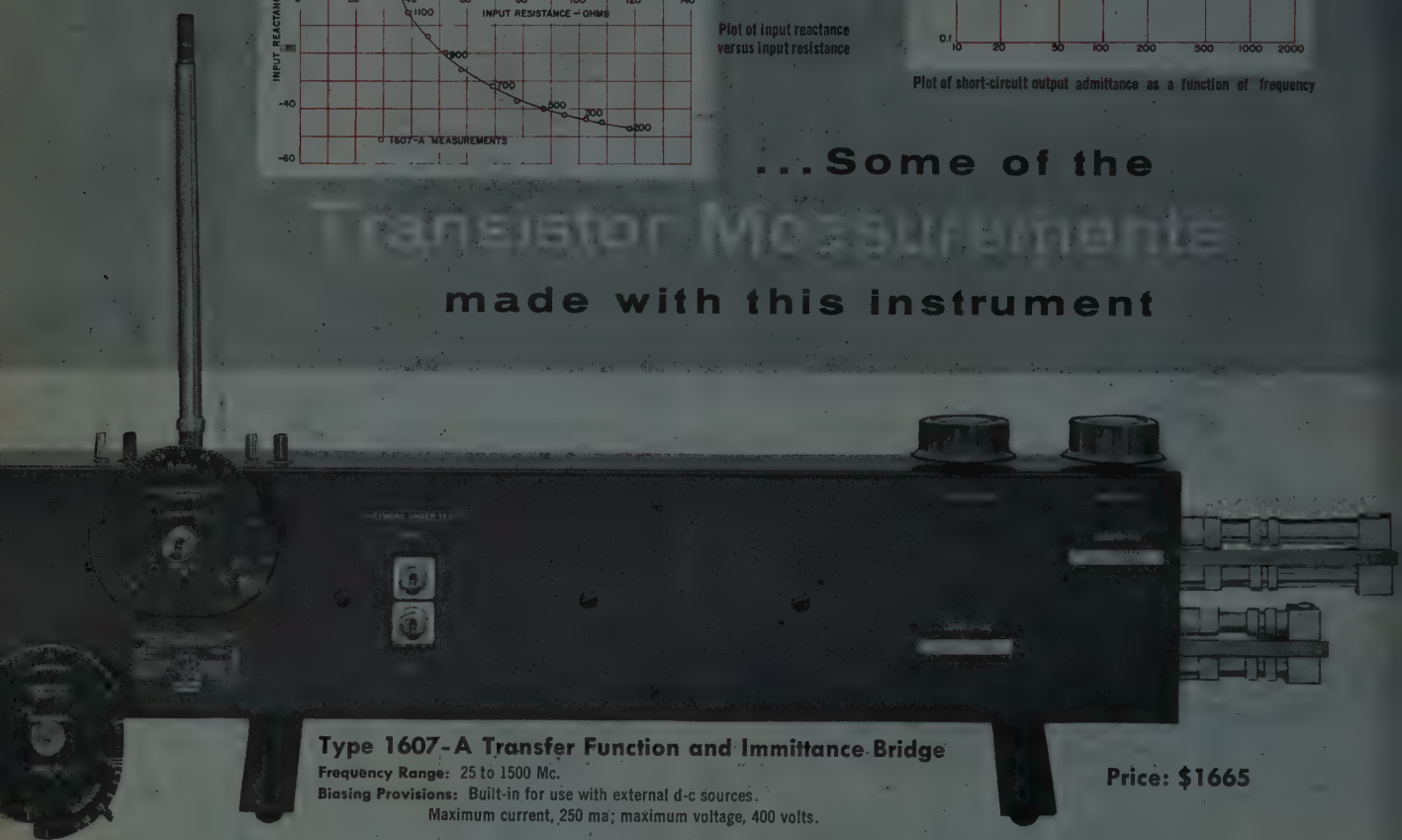


Plot of input reactance versus input resistance



Plot of short-circuit output admittance as a function of frequency

...Some of the Transistor Measurements made with this instrument



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Transadmittance (Y_{21})	0-600 mmhos	$2.5\left(1+\sqrt{\frac{Y_{21}}{20}}\right)\% + 0.5$ mmho
Impedance (Z_{11})	0-1000 ohms	$2.0\left(1+\sqrt{\frac{Z_{11}}{50}}\right)\% + 1.0$ ohm
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TO
ABSTRACTS
AND
REFERENCES
1960

VOLUME 48, NUMBER 6, PART II

June, 1960

published monthly by The Institute of Radio Engineers, Inc.

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Abbreviations used in the Index

a.c.	= alternating current	c.w.	= continuous wave
d.c.	= direct current	i.c.w.	= modulated c.w.
h.v.	= high voltage	m.c.w	= modulated c.w.
l.v.	= low voltage	s.w.*	= short wave
a.f.	= audio frequency	u.s.w.*	= ultra short wave
i.f.	= intermediate frequency	λ	= wavelength
r.f.	= radio frequency, including:—	c.r.	= cathode ray
v.l.f.	= very low frequency, <30 kc/s	c.r.o.	= cathode ray oscilloscope
l.f.	= low frequency, 30–300 kc/s	d.f.	= direction finding
m.f.	= medium frequency, 300–3000 kc/s	e.m.	= electromagnetic, *but*
h.f.	= high frequency, 3–30 Mc/s	e.m.f.	= electromotive force
v.h.f.	= very high frequency, 30–300 Mc/s	a.f.c.	= automatic frequency control
u.h.f.	= ultra high frequency, >300 Mc/s	a.g.c.	= automatic gain control
a.m.	= amplitude modulation	a.ph.c.	= automatic phase control
f.m.	= frequency modulation	a.v.c.	= automatic volume control
p.m.	= pulse modulation, including:—	m.u.f.	= maximum usable frequency
p.a.m.	= pulse amplitude modulation	p.p.i.	= plan position indicator
p.c.m.	= pulse code modulation	s.s.b.	= single sideband
p.f.m.	= pulse frequency modulation	d.s.b.	= double sideband
p.ph.m.	= pulse phase modulation	s.w.r.	= standing wave ratio
p.p.m.	= pulse position modulation	v.f.o.	= variable frequency oscillator
p.w.m.	= pulse width modulation	R/T	= radiotelephony
ph.m.	= phase modulation	W/T	= wireless telegraphy
v.m.	= velocity modulation	TV	= television

* No clearly defined limits

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515	Change U.D.C. number to 537.311.33 : 535.215
1052	For 'F. A. Vaniar' read 'F. A. Veniar'
1529	In line 5, for 'auroral' read 'annual'
1824	In line 7, for 'frequency band' read 'energy band'
1958	For 'J. F. Ditton, Jr' read 'J. F. Dillon, Jr'
1986	Change U.D.C. number to 621.384.8 : 537.54
2113	In line 4, for 'three-part' read 'three-port'
2159	In line 7, for 'joints' read 'points'
2278	In title, for 'Electric' read 'Elastic'
2408	In line 7, for '606-line' read '625-line'
2669	For 'S. Asanabo' read 'S. Asanabe'
2720	Change U.D.C. number to 621.384.8 : 537.54
2831	In title, for 'TE^o_{10}–TE^o_{21}' read 'TE^o_{10}–TE^o_{21}'
2857	In title, for '$m\sqrt{N}$' read '$N^{1/m}$'
2958	In line 4, for 'change-exchange' read 'charge-exchange'
3030	In line 5, for 'function' read 'junction'
3136	In line 5, for '3136' read '3138
3171	For 'W. R. Aitken' read 'W. R. Aiken'
3256	Change U.D.C. number to 538.566 : 535.42
3350	Change U.D.C. number to 537.311.3 : 539.23
3836	For 'J. L. Veshaeghe' read 'J. L. Verhaeghe'

IN PAPERS ABSTRACTED

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1405 of 1957	July 1957, Vol. AP-5, No. 3, p. 313
2959 of 1957	Dec. 1958, Vol. 5, No. 6, pp. 510–513
84 of 1958	Jan. 1959, Vol. 6, No. 1, p. 80
295 of 1958	Sept. 1959, Vol. 36, No. 9, p. 352
971 of 1958	Sept. 1958, Vol. 29, No. 9, p. 1383
1228 of 1958	Dec. 1959, Vol. 47, No. 12, p. 2105
1858 of 1958	April 1958, Vol. 3, No. 30, p. 312
1892 of 1958	April 1958, Vol. 3, No. 30, p. 312
3028 of 1958	Sept. 1958, Vol. 29, No. 9, p. 1383
3271 of 1958	Dec. 1959, Vol. 47, No. 12, p. 2084
3472 of 1958	Dec. 1958, Vol. 18, No. 12, p. 714
3544 of 1958	15th Dec. 1958, Vol. 112, No. 6, p. 2139
3890 of 1958	15th Sept. 1959, Vol. 115, No. 6, p. 1778
3902 of 1958	15th March 1959, Vol. 113, No. 6, p. 1697
3962 of 1958	Dec. 1958, Vol. 46, No. 12, p. 1913
173 of 1959	15th March 1959, Vol. 113, No. 6, p. 1696
239 of 1959	July 1957, Vol. AP-5, No. 3, p. 313
337 of 1959	Dec. 1957, Vol. CP-4, No. 4, pp. 135–137
379 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
385 of 1959	May 1959, Vol. 4, No. 39, p. 272
501 of 1959	1st June 1959, Vol. 73, No. 474, p. 976
635 of 1959	Oct. 1958, Vol. 17, No. 10, p. 117
745 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
855 of 1959	March 1959, Vol. 36, No. 3, p. 95
890 of 1959	March 1959, Vol. 9, Nos. 3/4, p. 340
1233 of 1959	15th June 1959, Vol. 114, No. 6, p. 1652
1368 of 1959	Sept. 1959, Vol. 47, No. 9, pp. 1653–1654
1372 of 1959	June 1958, Vol. 2, No. 3, p. 144
1493 of 1959	Dec. 1958, Vol. 17, No. 12, p. 36
1498 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
1559 of 1959	April 1959, Vol. 47, No. 4, p. 567
1615 of 1959	1st Sept. 1959, Vol. 3, No. 5, p. 244
1693 of 1959	Feb. 1959, Vol. 4, No. 37, p. 220
1795 of 1959	May 1959, Vol. 65, No. 5, p. 232
1952 of 1959	1st June 1959, Vol. 73, No. 474, p. 976
2024 of 1959	Oct. 1958, Vol. 2, No. 5, p. 252
2202 of 1959	15th June 1959, Vol. 114, No. 6, p. 1652
2408 of 1959	Aug. 1959, Vol. 36, No. 8, p. 314
2410 of 1959	July 1959, Vol. 47, No. 7, p. 1252
2503 of 1959	July 1959, Vol. 31, No. 377, p. 427
2750 of 1959	Aug. 1959, Vol. 47, No. 8, p. 1324
2841 of 1959	Jan. 1959, Vol. AP-7, No. 1, p. 104
3076 of 1959	Jan. 1959, Vol. 16, No. 1, p. 56
3077 of 1959	Jan. 1959, Vol. 16, No. 1, p. 56
3078 of 1959	April 1959, Vol. 14, No. 4, p. 547
3081 of 1959	Dec. 1958, Vol. 10, No. 12, p. 576
3419 of 1959	Oct. 1958, Vol. 2, No. 5, p. 252
3588 of 1959	Nov. 1959, Vol. 47, No. 11, p. 1840
3965 of 1959	July 1959, Vol. AP-7, No. 3, p. 251

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A

Acta Polytechnica Scandinavica, Publishing Office, Box 5073, Stockholm 5, Sweden. (*Acta polyt. scand.*)
Acustica, S. Hirzel Verlag, Stuttgart-N, Germany. (*Acustica*)
Advances in Physics, Taylor & Francis Ltd, Red Lion Court, Fleet Street, London, E.C.4, England. (*Advances Phys.*)
Akustícheskíĭ Zhurnal, Moskva, B-64, Podsosenskiĭ per., 21, U.S.S.R. (*Akust. Zh.*)
Akustische Beihefte, as for Acustica. (*Akust. Beihefte*)
Alta Frequenza, Associazione Elettrotecnica Italiana, Milano (202), Via S. Paolo 10, Italy. (*Alta Frequenza*)
Annalen der Physik, J. A. Barth, Leipzig C1, Salomonstrasse 18B, East Germany. (*Ann. Phys., Lpz.*)
Annales de Géophysique, Service des Publications du C.N.R.S., 13 Quai Anatole France, Paris 7e, France. (*Ann. Géophys.*)
Annales de Physique, Masson & Cie, 120 Boulevard Saint-Germain, Paris 6e, France. (*Ann. Phys., Paris*)
Annales de Radioélectricité, 10 rue Carducci, Paris 19e, France. (*Ann. Radioélect.*)
Annales des Télécommunications, 3 & 5 Boulevard Pasteur, Paris 15e, France. (*Ann. Télécommun.*)
Applied Scientific Research, Martinus Nijhoff, The Hague, Netherlands. (*Appl. sci. Res.*)
Archiv der elektrischen Übertragung, S. Hirzel Verlag, Stuttgart, Germany. (*Arch. elekt. Übertragung*)
Archiv für Elektrotechnik, Springer Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Germany. (*Arch. Elektrotech.*)
Archiv für technisches Messen, R. Oldenbourg KG, München 8, Rosenheimer Str. 145, Germany. (*Arch. tech. Messen*)
Arkiv för Fysik, published for Royal Swedish Academy of Sciences by Almqvist & Wiksell, Stockholm, Sweden. (*Ark. Fys.*)
A.T.E. Journal, Automatic Telephone & Electric Co. Ltd, Strowger Works, Liverpool 7, England. (*A.T.E. J.*)
Audio, Radio Magazines, Inc., P.O. Box 629, Mineola, N.Y., U.S.A. (*Audio*)
Australian Journal of Physics, Commonwealth Scientific and Industrial Research Organization, 314 Albert Street, East Melbourne C.2, Victoria, Australia. (*Aust. J. Phys.*)
Avtomatika i Telemekhanika, Moskva, I-53, Kalanchevskaya ul., 15a, U.S.S.R. (*Avtomatika i Telemekhanika*)
A.W.A. Technical Review, Amalgamated Wireless (Australasia) Ltd, Sydney, Australia. (*A.W.A. tech. Rev.*)

B

B.B.C. Engineering Division Monographs, British Broadcasting Corporation, 35 Marylebone High Street, London, W.1, England. (*B.B.C. Engng Div. Monographs*)
Beama Journal, British Electrical and Allied Manufacturers' Association, 36 Kingsway, London, W.C.2, England. (*Beama J.*)
Bell Laboratories Record, 463 West Street, New York 14, N.Y., U.S.A. (*Bell Lab. Rec.*)
Bell System Technical Journal, American Telephone and Telegraph Company, 195 Broadway, New York 7, N.Y., U.S.A. (*Bell Syst. tech. J.*)
British Communications & Electronics, Heywood & Co. Ltd, Drury House, Russell Street, Drury Lane, London, W.C.2, England. (*Brit. Commun. Electronics*)
British Journal of Applied Physics, 47 Belgrave Square, London, S.W.1, England. (*Brit. J. appl. Phys.*)
Brown Boveri Review, Baden, Switzerland. (*Brown Boveri Rev.*)
Bulletin de l'Association Suisse des Électriciens, Seefeldstrasse 301, Zürich 8, Switzerland. (*Bull. schweiz. elektrotech. Ver.*)
Bulletin of the Technical University Istanbul, Istanbul Teknik Universitesi, Gümüssuyu, Istanbul, Turkey. (*Bull. tech. Univ. Istanbul*)

C

Câbles & Transmission, Sotelec, 16 rue de la Baume, Paris 8e, France. (*Câbles & Transm.*)
Cahiers de Physique, 165 rue de Sèvres, Paris 15e, France. (*Cah. Phys.*)
Canadian Electronics Engineering, Maclean-Hunter Publishing Co. Ltd, P.O. Box 100, Toronto, Canada. (*Canad. Electronics Engng*)
Canadian Journal of Physics, National Research Council, Ottawa 2, Ont., Canada. (*Canad. J. Phys.*)
Chalmers tekniska Högskolas Handlingar Gumperts Förlag, Göteborg, Sweden. (*Chalmer. tek. Högsk. Handl.*)
Communication and Electronics, American Institute of Electrical Engineers, 20th and Northampton Streets, Easton, Pa, U.S.A. (*Commun. & Electronics*)
Communications on Pure and Applied Mathematics, Interscience Publishers Inc., 250 Fifth Avenue, New York 1, N.Y., U.S.A. (*Commun. pure appl. Math.*)
Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, Gauthier-Villars, 55 Quai des Grands-Augustins, Paris 6e, France. (*C. R. Acad. Sci., Paris*)

D

Doklady Akademii Nauk S.S.S.R., Moskva, B-64, Podsosenskii per., 21, U.S.S.R. (*Dokl. Ak. Nauk S.S.S.R.*)

E

E.B.U. Review, 32 Avenue Albert Lancaster, Bruxelles 18, Belgium. (*E.B.U. Rev.*)
Electrical Communication, International Telephone and Telegraph Corporation, 67 Broad Street, New York 4, N.Y., U.S.A. (*Elect. Commun.*)
Electrical Engineering, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N.Y., U.S.A. (*Elect. Engng, N.Y.*)
Electrical Journal, Bouverie House, 154 Fleet Street, London, E.C.4, England. (*Elect. J.*)
Electrical Manufacturing, 205 East 42nd Street, New York 17, N.Y., U.S.A. (*Elect. Mfg*)
Electrical Review, Dorset House, Stamford Street, London, S.E.1, England. (*Elect. Rev., Lond.*)
Electronic Applications, N. V. Philips' Gloeilampenfabrieken, Technical and Scientific Literature Department, Eindhoven, Netherlands. (*Electronic Applic.*)
Electronic Engineering, 28 Essex Street, London, W.C.2, England. (*Electronic Engng*)
Electronic Equipment Engineering, Sutton Publishing Company Inc., 172 South Broadway, White Plains, N.Y., U.S.A. (*Electronic Equipm. Engng*)
Electronic Industries, Chestnut and 56th Sts, Philadelphia 39, Pa, U.S.A. (*Electronic Ind.*)
Electronic & Radio Engineer, Iliffe & Sons Ltd, Dorset House, Stamford Street, London, S.E.1, England. (*Electronic Radio Engr*)
Electronics, 330 West 42nd Street, New York 36, N.Y., U.S.A. (*Electronics*)
Elektronische Rundschau, Verlag für Radio-Foto-Kinotechnik G.m.b.H., Berlin-Borsigwalde, Eichborndamm 141–167, Germany. (*Elektronische Rundschau*)
Elektrosvyaz', Moskva, K-9, ul. Gor'kogo, 7, 8-I pod"ezd, 3-I etazh, U.S.S.R. (*Elektrosvyaz'*)
Elektrotechnik und Maschinenbau, Journal of the Elektrotechnischer Verein Österreichs, Springer Verlag, Wien I, Mölkerbastei 5, Austria. (*Elektrotech. u. Maschinenb.*)
Elektrotechnische Zeitschrift, Edition A & B, VDE-Verlag G.m.b.H., Berlin-Charlottenburg 2, Bismarckstrasse 33, Germany. (*Elektrotech. Z.*)
Endeavour, Imperial Chemical Industries Ltd, North Block, Thames House, Millbank, London, S.W.1, England. (*Endeavour*)
Engineer, 28 Essex Street, London, W.C.2, England. (*Engineer, Lond.*)
Engineering, 36 Bedford Street, London, W.C.2, England. (*Engineering, Lond.*)
Ericsson Review, Telefonaktiebolaget L. M. Ericsson, Stockholm 32, Sweden. (*Ericsson Rev.*)
Ericsson Technics, as for Ericsson Review. (*Ericsson Tech.*)

F

Fizika Tverdogo Tela, Leningrad, V-164, Mendeleevskaya lin., 1, U.S.S.R. (*Fiz. Tverdogo Tela*)
Frequenz, Fachverlag Schiele & Schön G.m.b.H., Berlin S.W.61, Markgrafenstrasse 11, Germany. (*Frequenz*)
Funk-Technik, Verlag für Radio-Foto-Kinotechnik G.m.b.H., Berlin-Borsigwalde, Eichborndamm 141–167, Germany. (*Funk-Technik, Berlin*)

G

G.E.C. Journal, General Electric Company Ltd, Magnet House, Kingsway, London, W.C.2, England. (*G.E.C. J.*)
G.E.C. Telecommunications, General Electric Company Ltd, Coventry, England. (*G.E.C. Telecommun.*)
Geofisica Pura e Applicata, Istituto Geofisico Italiano, Milano, Piazza Leonardo da Vinci 12, Italy. (*Geofis. pura appl.*)
Geophysical Journal of the Royal Astronomical Society, Burlington House, London, W.1, England. (*Geophys. J. R. astr. Soc.*)

H

Helvetica Physica Acta, Journal of the Schweizerische Physikalische Gesellschaft, Birkhäuser Verlag, Basel, Switzerland. (*Helv. phys. Acta*)
Hochfrequenztechnik und Elektroakustik, Akademische Verlagsgesellschaft Geest & Portig K.-G., Leipzig C1, Sternwartenstr. 8, East Germany. (*Hochfrequenztech. u. Elektroakust.*)

I

IBM Journal of Research and Development, International Business Machines Corporation, 590 Madison Avenue, New York 22, N.Y., U.S.A. (*IBM J. Res. Develop.*)
Indian Journal of Physics (and Proceedings of the Indian Association for the Cultivation of Science), Jadavpur, Calcutta 32, India. (*Indian J. Phys.*)
Izvestiya Akademii Nauk S.S.S.R. (*a*) seriya fizicheskaya, Moskva, B-64, Podsosenskii per., 21, U.S.S.R., (*b*) seriya geofizicheskaya, Moskva, B. Gruzinskaya ul., 10, U.S.S.R., (*c*) otdelenie tekhnicheskikh nauk, Moskva, M. Khariton'evskii per., 4, U.S.S.R. (*Izv. Ak. Nauk S.S.S.R., (a) ser. fiz., (b) ser. geofiz., (c) otd.-tekh. nauk*)

J

Journal of the Acoustical Society of America, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*J. acoust. Soc. Amer.*)
Journal of the American Ceramic Society, 20th and Northampton Streets, Easton, Pa, U.S.A. (*J. Amer. ceram. Soc.*)
Journal of Applied Physics, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*J. appl. Phys.*)
Journal of Atmospheric and Terrestrial Physics, Pergamon Press Ltd, 4 & 5 Fitzroy Square, London, W.1, England. (*J. atmos. terr. Phys.*)
Journal of the Audio Engineering Society, P.O. Box 12, Old Chelsea Station, New York 11, N.Y., U.S.A. (*J. audio Engng Soc.*)
Journal of the British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1, England. (*J. Brit. Instn Radio Engrs*)
Journal of the British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1, England. (*J. Brit. interplan. Soc.*)
Journal of the Electrochemical Society, 1860 Broadway, New York 23, N.Y., U.S.A. (*J. electrochem. Soc.*)
Journal of Electronics and Control, Taylor & Francis Ltd, Red Lion Court, Fleet Street, London, E.C.4, England. (*J. Electronics Control*)
Journal of the Franklin Institute, Benjamin Franklin Parkway at Twentieth Street, Philadelphia 3, Pa, U.S.A. (*J. Franklin Inst.*)
Journal of Geomagnetism and Geoelectricity, Society of Terrestrial Magnetism and Electricity of Japan, Geophysical Institute, Kyoto University, Kyoto, Japan. (*J. Geomag. Geoelect.*)
Journal of Geophysical Research, 1515 Massachusetts Avenue, N.W., Washington 5, D.C., U.S.A. (*J. geophys. Res.*)
Journal of the Indian Institute of Science, Indian Institute of Science, Bangalore 12, India. (*J. Indian Inst. Sci.*)
Journal of the Institute of Navigation, John Murray Ltd, 50 Albemarle Street, London, W.1, England. (*J. Inst. Nav.*)
Journal of the Institution of Telecommunication Engineers, Post Box 481, New Delhi, India. (*J. Instn Telecommun. Engrs, India*)
Journal of Mathematics and Physics, Massachusetts Institute of Technology, Cambridge 39, Mass., U.S.A. (*J. Math. Phys.*)
Journal of Meteorology, Prince and Lemon Streets, Lancaster, Pennsylvania, U.S.A. (*J. Met.*)
Journal of the Optical Society of America, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*J. opt. Soc. Amer.*)
Journal of the Physical Society of Japan, Maruzen Publishing Co., P.O. Box 605 Central, Tokyo, Japan. (*J. phys. Soc. Japan*)
The Journal of the Physics and Chemistry of Solids, Pergamon Press Ltd, 4 & 5 Fitzroy Square, London, W.1, England. (*J. Phys. Chem. Solids*)
Journal de Physique et le Radium, 12 place Henri-Bergson, Paris 8e, France. (*J. Phys. Radium*)
Journal of the Radio Research Laboratories, Ministry of Posts and Telecommunications, Koganei-shi, Tokyo, Japan. (*J. Radio Res. Labs, Japan*)
Journal of Research of the National Bureau of Standards, U.S. Government Printing Office, Washington 25, D.C., U.S.A. (*J. Res. nat. Bur. Stand.*)
Journal of Scientific Instruments, 47 Belgrave Square, London, S.W.1, England. (*J. sci. Instrum.*)
Journal of the Society of Motion Picture and Television Engineers, 55 West 42nd Street, New York 36, N.Y., U.S.A. (*J. Soc. Mot. Pict. Telev. Engrs*)
Journal of the Television Society, 166 Shaftesbury Avenue, London, W.C.2, England. (*J. Telev. Soc.*)

M

Marconi Review, Marconi House, Chelmsford, England. (*Marconi Rev.*)
Metal Industry, Iliffe & Sons Ltd, Dorset House, Stamford Street, London, S.E.1, England. (*Metal Ind., Lond.*)
Metallurgia, 31 King Street West, Manchester 3, England. (*Metallurgia, Mancr.*)
Meteorological Magazine, Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2, England. (*Met. Mag., Lond.*)
Microtecnic, 23 Avenue de la Gare, Lausanne, Switzerland. (*Microtecnic*)
Modern Plastics, 575 Madison Avenue, New York 22, N.Y., U.S.A. (*Mod. Plast.*)
Monthly Notices of the Royal Astronomical Society, Burlington House, London, W.1, England. (*Mon. Not. R. astr. Soc.*)
Mullard Technical Communications, Mullard House, Torrington Place, London, W.C.1, England. (*Mullard tech. Commun.*)

N

Nachrichtentechnik, V.E.B. Verlag Technik, Berlin C2, Oranienburger Str. 13/14, East Germany. (*NachrTech.*)
Nachrichtentechnische Zeitschrift, F. Vieweg & Sohn, (20b) Braunschweig, Burgplatz 1, Germany. (*Nachrichtentech. Z.*)
Nature, Macmillan & Co. Ltd, St. Martin's Street, London, W.C.2, England. (*Nature, Lond.*)
Naturwissenschaften, Springer Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Germany. (*Naturwissenschaften*)
Note Recensioni e Notizie, Istituto Superiore delle Poste e delle Telecomunicazioni, Viale Trastevere 189, Roma, Italy. (*Note Recensioni Notiz.*)
Nucleonics, 330 West 42nd Street, New York 36, N.Y., U.S.A. (*Nucleonics*)
Nuovo Cimento, Editore Nicola Zanichelli, Bologna, Via Irnerio 34, Italy. (*Nuovo Cim.*)

O

Observatory, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex, England. (*Observatory*)
l'Onde Électrique, Éditions Chiron, 40, rue de Seine, Paris 6e, France. (*Onde électr.*)
Optik, Wissenschaftliche Verlagsgesellschaft m.b.H., Stuttgart 1, Postfach 40, Germany. (*Optik, Stuttgart*)

P

Philips Research Reports, N.V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. (*Philips Res. Rep.*)
Philips Technical Review, as for Philips Research Reports. (*Philips tech. Rev.*)
Philips Telecommunication Review, Philips Telecommunication Division, P.O. Box 32, Hilversum, Netherlands. (*Philips Telecommun. Rev.*)
Philosophical Magazine, Taylor & Francis Ltd, Red Lion Court, Fleet Street, London, E.C.4, England. (*Phil. Mag.*)
Philosophical Transactions of the Royal Society, Burlington House, Piccadilly, London, W.1, England. (*Phil. Trans.*)
Physica, Physica Foundation, Lucas Bolwerk 4, Utrecht, Netherlands. (*Physica*)
Physical Review, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*Phys. Rev.*)
Physical Review Letters, American Institute of Physics, 335, East 45th Street, New York 17, N.Y., U.S.A. (*Phys. Rev. Lett.*)
Physics and Chemistry of Solids. See Journal of the Physics and Chemistry of Solids.
Point to Point Telecommunications, Communications Division, Marconi's Wireless Telegraph Co. Ltd, Chelmsford, England. (*Point to Point Telecommun.*)
Post Office Electrical Engineers' Journal, Engineer-in-Chief's Office, Alder House, Aldersgate Street, London, E.C.1, England. (*P.O. elect. Engrs' J.*)
Poste e Telecomunicazioni, Roma, Via della Vite 107, Italy. (*Poste e Telecommunicazioni*)
Priroda, Moskva, Tsentr, Malyi Khariton'evskii per., 4, U.S.S.R. (*Priroda, Mosk.*)
Proceedings of the Cambridge Philosophical Society (Mathematical and Physical Sciences), Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1, England. (*Proc. Camb. phil. Soc.*)
Proceedings of the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y., U.S.A. (*Proc. Inst. Radio Engrs*)
Proceedings of the Institution of Electrical Engineers, Parts A, B and C, Savoy Place, London, W.C.2, England. (*Proc. Instn elect. Engrs*)
Proceedings of the Institution of Radio Engineers, Australia, Science House, 157 Gloucester Street, Sydney, N.S.W., Australia. (*Proc. Instn Radio Engrs Aust.*)
Proceedings of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, England. (*Proc. phys. Soc.*)
Proceedings of the Royal Society, Burlington House, Piccadilly, London, W.1, England. (*Proc. roy. Soc.*)
Progress of Theoretical Physics, The Publication Office, Yukawa Hall, Kyoto University, Kyoto, Japan. (*Progr. theor. Phys.*)

Q

QST, American Radio Relay League Inc., 38 La Salle Road, West Hartford 7, Conn., U.S.A. (*QST*)
Quarterly of Applied Mathematics, Brown University, Providence 12, R.I., U.S.A. (*Quart. appl. Math.*)
Quarterly Journal of Mathematics, Oxford University Press, Amen House, London, E.C.4, England. (*Quart. J. Math.*)
Quarterly Journal of Mechanics and Applied Mathematics, Oxford University Press, Amen House, London, E.C.4, England. (*Quart. J. Mech. appl. Math.*)
Quarterly Journal of the Royal Meteorological Society, 49 Cromwell Road, London, S.W.7, England. (*Quart. J. R. met. Soc.*)

R

Radio, Moskva, B-66, Novo-Ryazanskaya ul., 26, U.S.S.R. (*Radio, Mosk.*)
Radio & TV News, Ziff-Davis Publishing Company, 434 South Wabash Avenue, Chicago 5, Ill., U.S.A. (*Radio TV News*)
Radio-Electronics, 154 West 14th St., New York 11, N.Y., U.S.A. (*Radio-Electronics*)
Radioschau, Technischer Verlag Erb, Wien VI, Mariahilferstrasse 71, Austria. (*Radioschau*)
Radiotekhnika, Moskva, K-9, ul. Gor'kogo, 7, 3-I pod"ezd, U.S.S.R. (*Radiotekhnika, Mosk.*)
Radiotekhnika i Elektronika, Moskva, K-9, Mokhovaya, 11, U.S.S.R. (*Radiotekhnika i Elektronika*)
RCA Review, RCA Laboratories, Princeton, N.J., U.S.A. (*RCA Rev.*)
Referativnyi Zhurnal, Fizika, Moskva, D-129, Baltiiskaya ul., 14, U.S.S.R. (*Referativnyi Zh. Fiz.*)
Report of Ionosphere Research in Japan, Ionosphere Research Committee, Science Council of Japan, Ueno Park, Tokyo, Japan. (*Rep. Ionosphere Res. Japan*)
Reports of the Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation, 1551 Kichijoji, Musashino-shi, Tokyo, Japan. (*Rep. elect. Commun. Lab., Japan*)
Research, Butterworth's Scientific Publications Ltd, 88 Kingsway, London, W.C.2, England. (*Research, Lond.*)
Review of Scientific Instruments, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*Rev. sci. Instrum.*)
Reviews of Modern Physics, American Institute of Physics, 335 East 45th Street, New York 17, N.Y., U.S.A. (*Rev. mod. Phys.*)
Revista Española de Electrónica, Apartado 5252, Barcelona, Spain. (*Rev. española Electrónica*)
Revista de Telecomunicación, Palacio de Comunicaciones, Madrid, Spain. (*Rev. Telecommunicación, Madrid*)
Revista Telegrafica Electrónica, Arbó Editores, Buenos Aires, Argentina. (*Res. telegr. Electrónica, Buenos Aires*)
Revue générale de l'Électricité, 12 place Henri-Bergson, Paris 8e, France. (*Rev. gén. Elect.*)
Revue HF, 55 rue Defacqz, Bruxelles, Belgium. (*Rev. HF, Brussels*)
Revue d'Optique, 3 & 5 Boulevard Pasteur, Paris 15e, France. (*Rev. d'Optique*)
Ricerca scientifica, Consiglio Nazionale delle Ricerche, Piazzale delle Scienze, 7, Roma, Italy. (*Ricerca sci.*)
R.S.G.B. Bulletin, New Ruskin House, Little Russell Street, London, W.C.1, England. (*R.S.G.B. Bull.*)
Rundfunktechnische Mitteilungen, H. H. Nölke G.m.b.H., Hamburg 20, Hegestrasse 40, Germany. (*Rundfunktech. Mitt.*)

S

Science, 1515 Massachusetts Avenue, N.W., Washington 5, D.C., U.S.A. (*Science*)
Science Reports of the Research Institutes Tohoku University, Series A and B, Tohoku University, Sendai, Japan. (*Sci. Rep. Res. Inst. Tohoku Univ.*)
Short Wave Magazine, 55 Victoria Street, London, S.W.1, England. (*Short Wave Mag.*)
Sylvania Technologist, Sylvania Electric Products Inc., Bayside, N.Y., U.S.A. (*Sylvania Technologist*)

T

Technical News Bulletin of the National Bureau of Standards, U.S. Government Printing Office, Washington 25, D.C., U.S.A. (*Tech. News Bull. nat. Bur. Stand.*)
Technische Mitteilungen aus dem Betriebslaboratorium für Rundfunk und Fernsehen, Agastrasse, Berlin-Adlershof, East Germany. (*Tech. Mitt. BRF, Berlin*)
Technische Mitteilungen PTT, Journal of the Swiss Post Office, Bern, Speichergasse 6, Switzerland. (*Tech. Mitt. PTT*)
Telefunken Zeitung, Telefunken G.m.b.H., Berlin-Charlottenburg 1, Ernst-Reuter-Platz, Haus der Elektrizität, Germany. (*Telefunken Ztg*)
Télévision, 42 rue Jacob, Paris 6e, France. (*Télévision*)
Tellus, Lindhagensgatan 124, Stockholm, Sweden. (*Tellus*)
Tijdschrift van het Nederlands Radiogenootschap, Jagtlustlaan 9, Santpoort-Zuid, Netherlands. (*Tijdschr. ned. Radiogenoot.*)
Toute la Radio, 9 rue Jacob, Paris 6e, France. (*Toute la Radio*)
Transactions of the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y., U.S.A. (*Trans. Inst. Radio Engrs*)
Transactions of the South African Institute of Electrical Engineers, The Associated Scientific and Technical Societies of South Africa, P.O. Box 5907, Johannesburg, South Africa. (*Trans. S. Afr. Inst. elect. Engrs*)
TSF et TV, Editions Chiron, 40 rue de Seine, Paris 6e, France. (*TSF et TV*)

U

Uspekhi Fizicheskikh Nauk, Moskva, V-71, Leninskii Prospekt, 15, U.S.S.R. (*Usp. fiz. Nauk*)

V

Le Vide, Journal of the Société française des Ingénieurs et Techniciens du Vide, 44 rue de Rennes, Paris 6e, France. (*Le Vide*)

W

Weather, 49 Cromwell Road, London, S.W.7, England. (*Weather*)
Wireless World, Iliffe & Sons Ltd, Dorset House, Stamford Street, London, S.E.1, England. (*Wireless World*)

Z

Zeitschrift für angewandte Mathematik und Physik, Birkhäuser-Verlag, Basel, Switzerland. (*Z. angew. Math. Phys.*)
Zeitschrift für angewandte Physik, Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Germany. (*Z. angew. Phys.*)
Zeitschrift für Metallkunde, Dr. Riederer-Verlag G.m.b.H., Stuttgart, Marienstrasse 52, Germany. (*Z. Metallkde*)
Zeitschrift für Meteorologie, Akademie-Verlag G.m.b.H., Berlin W.1, Leipziger Strasse 3–4, East Germany. (*Z. Met.*)
Zeitschrift für Naturforschung, (14b) Tübingen, Postfach 61, Germany. (*Z. Naturf.*)
Zeitschrift für Physik, Springer-Verlag, Berlin, Wilmersdorf, Heidelberger Platz 3, Germany (*Z. Phys.*)
Zhurnal eksperimental'noi i teoreticheskoi Fiziki, Moskva, V-133, Vorob'evskoe shosse, 2, U.S.S.R. (*Zh. eksp. teor. Fiz.*)
Zhurnal tekhnicheskoi Fiziki, Leningrad V-164, Mendeleevskaya lin., 1, U.S.S.R. (*Zh. tekh. Fiz.*)